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TECH BRIEFS

THE DESIGN/ENGINEERING TECHNOLOGY DIGEST

Visualization Tools Reveal Storm Secrets

Technology 2007 Preview, Page 22

Data Acquisition & Analysis

New England Tech Showcase

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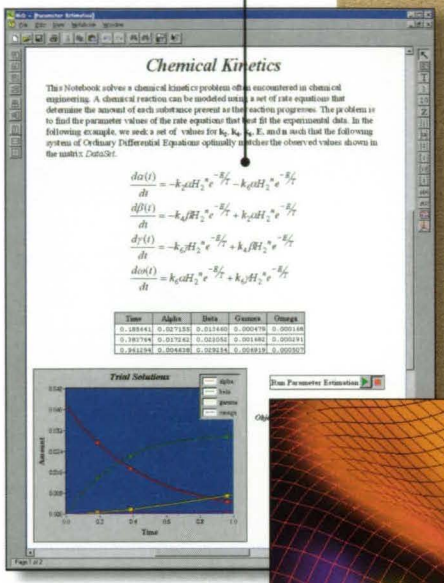

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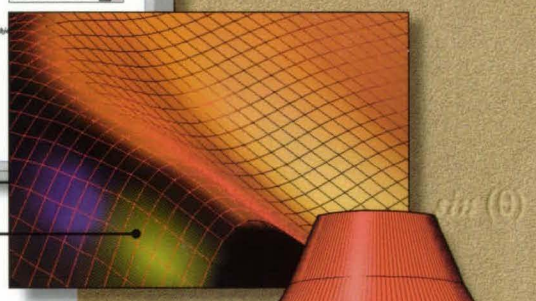

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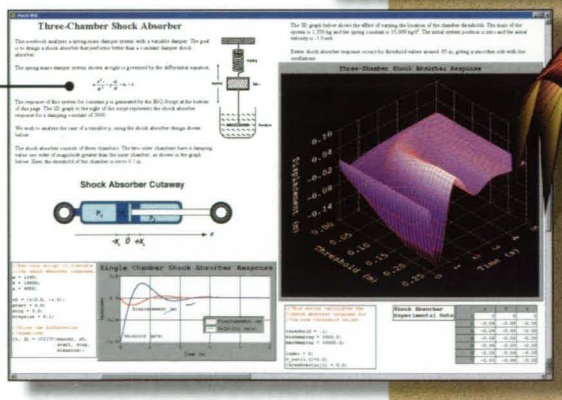

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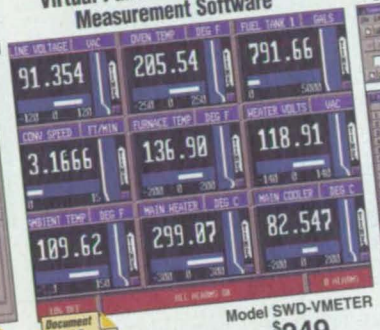

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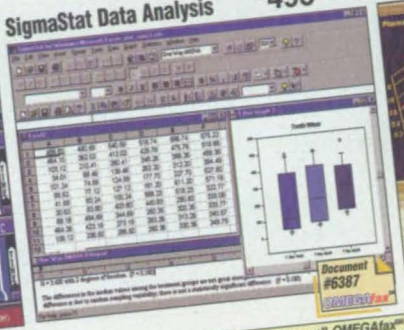

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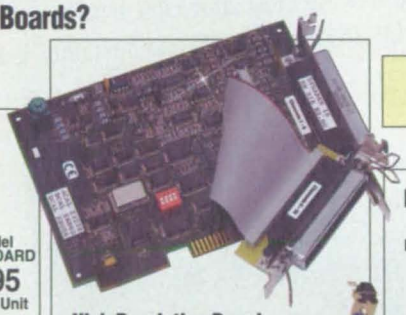

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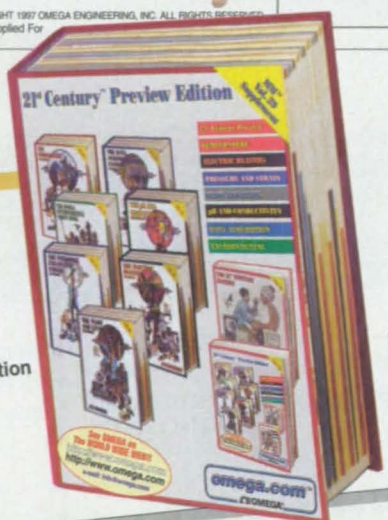

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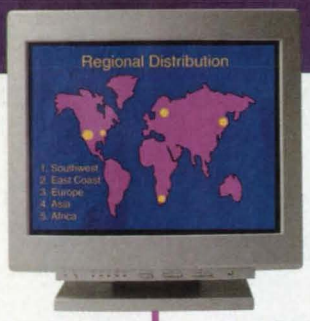

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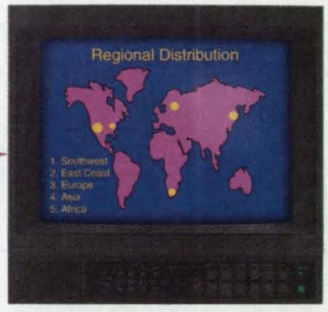

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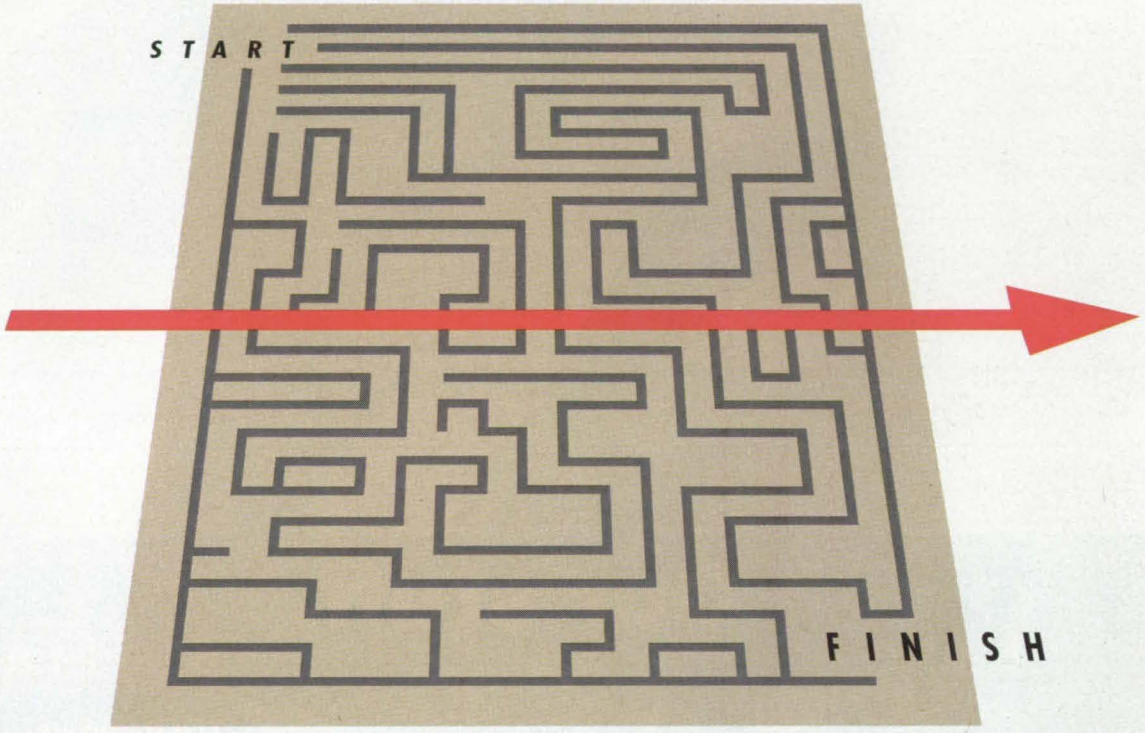

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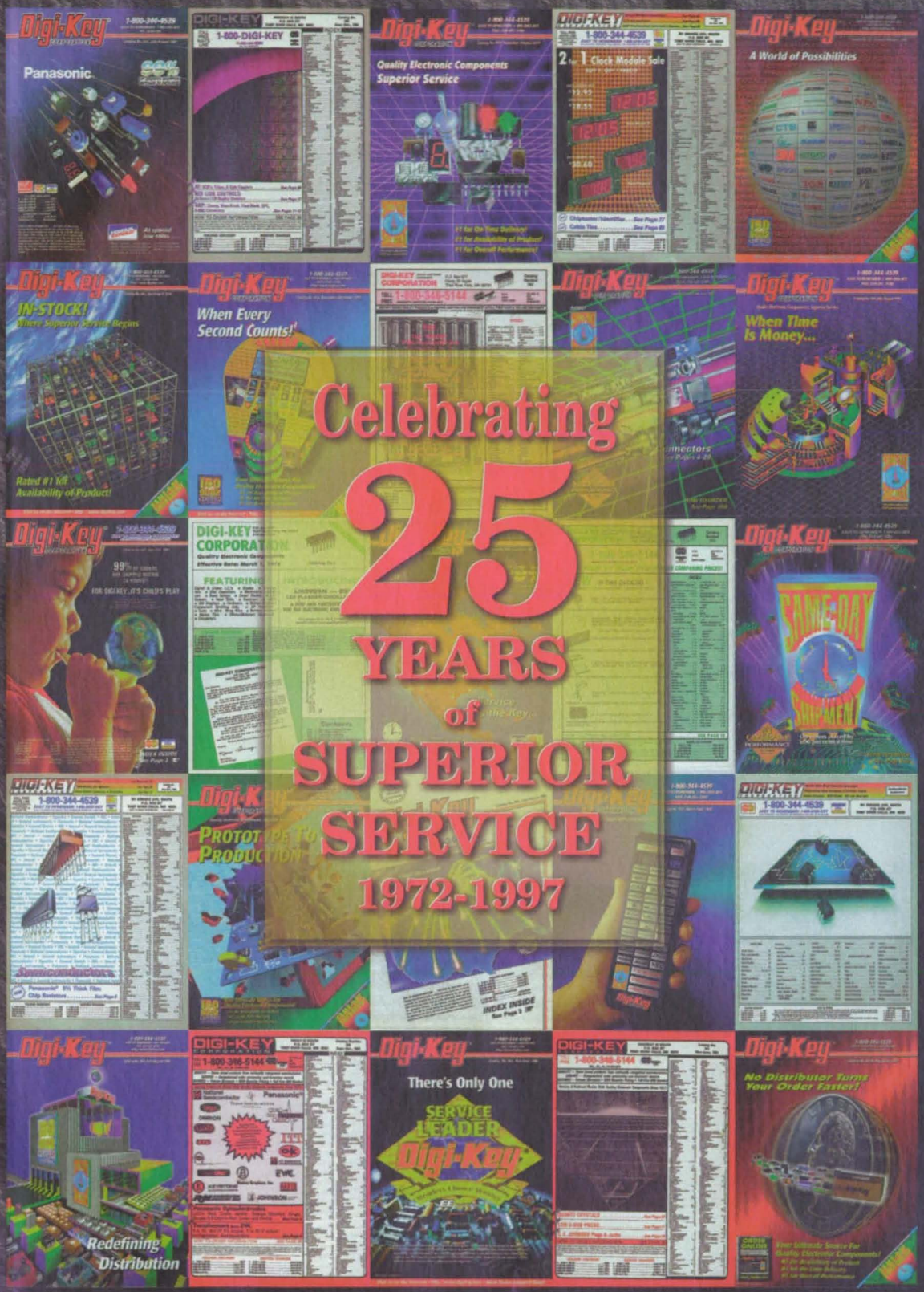

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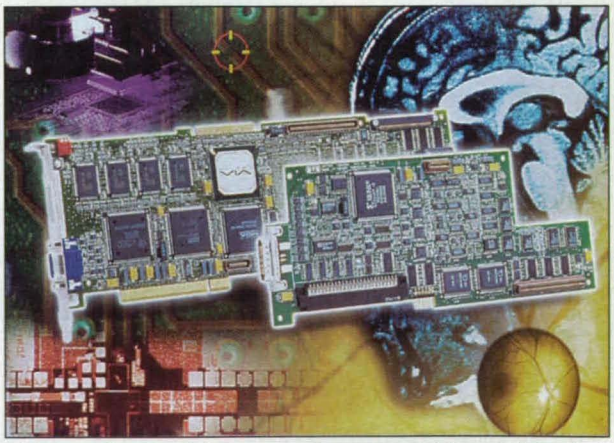
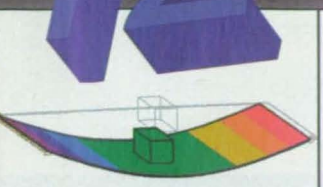


This month's Special Focus on Data Acquisition and Analysis features advanced techniques in data transmission, communication, processing, and measuring. The Genesis-LC PCI framegrabber analog/digital data capture board from Matrox Imaging Products of Dorval, Quebec, Canada, is one of the new data acquisition/analysis products also featured in this section, which begins on page 32.

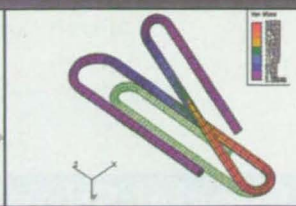
Photo courtesy of Matrox Imaging Products

Now: NONLINEAR that's EASY

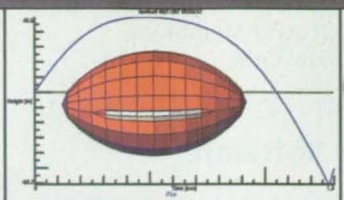
12 EASY things you can do with Nonlinear that you can't do with regular linear stress analysis



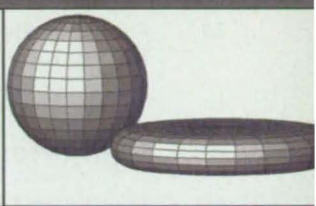
Out of plane bending - Use nonlinear analysis to determine whether this plate will foreshorten and fall out of its support. Linear cannot predict geometry changes perpendicular to a load.



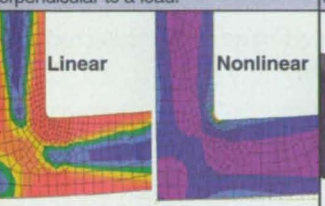
Permanent deformation - Algor's nonlinear analysis can predict the permanent deformation when the predicted stress exceeds the yield stress. Linear analysis can't do this.



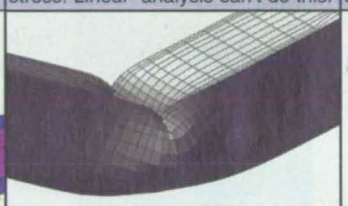
Trajectory - Basic motion, such as the trajectory of this rotating football is easily done using Algor's nonlinear analysis. Linear analysis cannot predict motion.



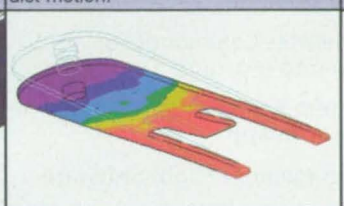
Squashing - Squashing this rubb ball in a vice using linear analys cannot predict the final shape like t nonlinear analysis.



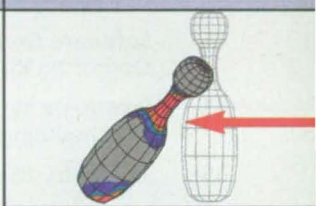
Stress concentration - Linear stress analysis will misrepresent both the stress and the deformation of this hanger due to minute changes in the fillet. Nonlinear analysis gets it right.



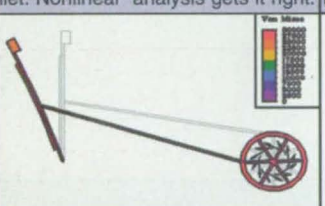
Local buckling - When failure is due to local buckling, the geometry fails at stresses much, much lower than the yield stress. Linear cannot detect local buckling.



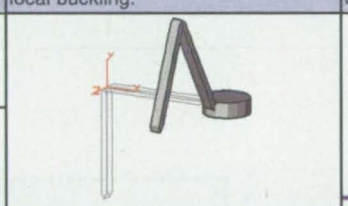
Snap-through - Any time you have a snap-through effect, your part is in motion until it stops on the other side. You need nonlinear analysis to predict this effect.



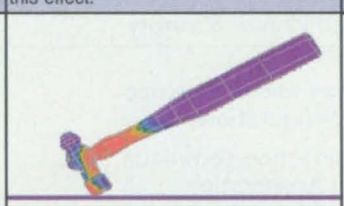
Impact - Nonlinear dynamic respon predicts the stress in an object when goes into motion as a result of impact another object. Linear analysis cann analyze for impact and motion.



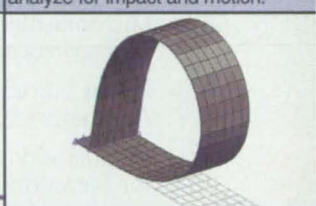
4-bar link - Linear dynamic analysis cannot predict the forces and stresses due to periodic loading. Accupak/VE simulates the loading and stresses in one analysis.



3-D mechanism - When a moving object is a 3-D mechanism, high inertia forces can occur. You need Accupak/VE to predict the stresses caused by motion.



Contact impact - Kinematic motion and the stresses due to the shock of impact cannot be predicted by either linear stress analysis or kinematics analysis software. Accupak/VE does it in one shot..



Elastic large deformation - Nonline analysis predicts the stressed geome when the deformation is significa even if the material properties rema linear. Linear analysis fails at this.

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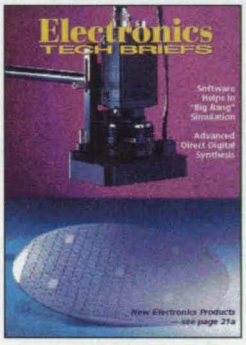
Special Supplement



Electronic Tech Briefs

Follows page 34N in selected editions only.

On the cover:

Produced by the NASA Goddard Laboratory for Atmospheres, this image is a visualization of Hurricane Danny obtained on July 19, 1997 at 10:00 am CST in the Gulf of Mexico nearing Alabama. The image was obtained using the NOAA GOES 08 satellite's visible and four-micrometer infrared channels. The techniques used to visualize and analyze the immense remote sensing data sets and 3D numerical models will be presented by Fritz Hasler of NASA Goddard at Technology 2007 later this month in Boston. For more information on this session and other innovations to be featured at the show, see What's New at Technology 2007, beginning on page 22.

Image courtesy of NASA Goddard

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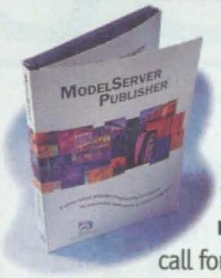

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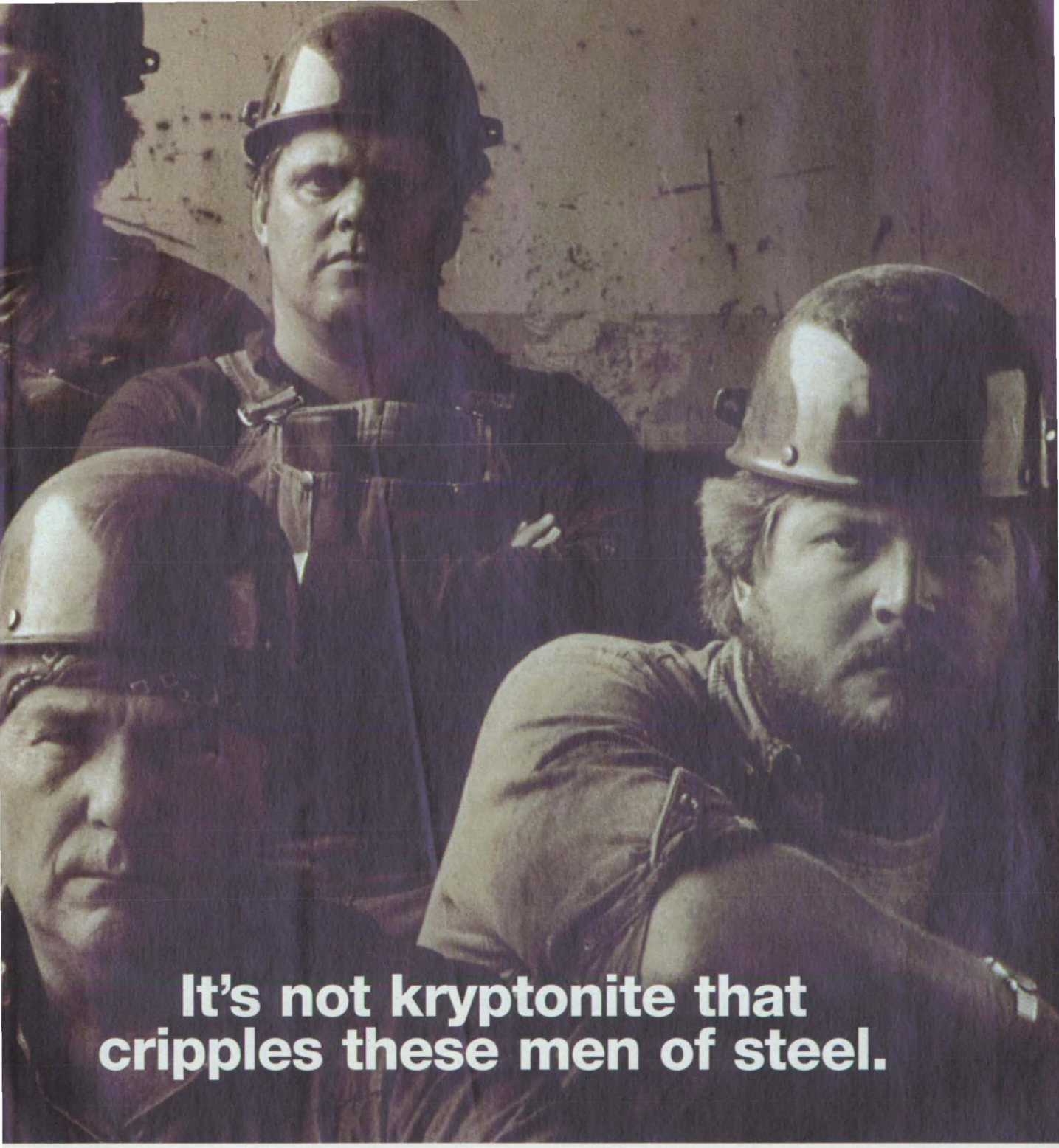

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It's downtime. At Bethlehem Steel's Burns Harbor Division, the prognosis was 16 weeks of downtime for one of the plant's BOFs after a 40" diameter shaft broke, damaging the bearing, and leaving the 300-ton steelmaking furnace standing idle. A superhuman effort would be needed to return the furnace to service quickly and keep lost production to a minimum. The team of experts that immediately went to work included Torrington's bearing specialists. Now, we're not asked to move faster than a speeding bullet every day, but in less than one month (some termed the effort "miraculous") we had reconditioned and supervised reinstallation of the monster bearing. Which bearing company would you rather have on your team when trouble strikes?

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NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (206) 683-1005 for the FLC coordinator in your area.

NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Bruce Webbon
(415) 604-6646
bwebbon@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3802
duke@louie.dfrf.nasa.gov

Goddard Space Flight Center
Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Command.
George Alcorn
(301) 286-5810
galcorn@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Merle McKenzie
(818) 354-2577
merle.mckenzie@ccmail.jpl.nasa.gov

Johnson Space Center
Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
Hank Davis
(713) 483-0474
hdavis@gp101.jsc.nasa.gov

Kennedy Space Center
Selected technological strengths: Environmental Monitoring; Sensors; Corrosion Protection; Bio-Sciences; Process Modeling; Work Planning/Control; Meteorology.
Gale Allen
(407) 867-8035
galeallen-1@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Dr. Joseph S. Heyman
(804) 864-6006
j.s.heyman@larc.nasa.gov

Lewis Research Center
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Ann Heyward
(216) 433-3484
cto@lerc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Harry Craft
(205) 544-5419
harry.craft@msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Kirk Sharp
(601) 688-1929
ksharp@ssc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional Technology Transfer Center nearest you, call (800) 472-6785.

Dr. David Moran
National Technology Transfer Center
(800) 678-6882

Ken Dozier
Far-West Technology Transfer Center
University of Southern California
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Dr. William Gasko
Center for Technology Commercialization
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Gary Sera
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Lani S. Hummel
Mid-Atlantic Technology Applications Center
University of Pittsburgh
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Chris Coburn
Great Lakes Industrial Technology Transfer Center
Battelle Memorial Institute
(216) 734-0094

NASA ON-LINE: Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at **http://nctn.hq.nasa.gov** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

Carl Ray
Small Business Innovation Research Program (SBIR) & Small Business Technology Transfer Program (STTR)
(202) 358-4652
cray@mail.hq.nasa.gov

Dr. Robert Norwood
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Office of Mission to Planet Earth (Code Y)
(202) 358-0706
gpaules@mtpe.hq.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Karen Robbins
American Technology Initiative
Menlo Park, CA
(415) 325-5353

Dr. Jill Fabricant
Johnson Technology Commercialization Center
Houston, TX
(713) 335-1250

Wayne P. Zeman
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Mississippi Enterprise for Technology
Stennis Space Center, MS
(800) 746-4699

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622. For software developed with NASA funding, contact the **Computer Software Management and Information Center (COSMIC)** at phone: (706) 542-3265; Fax: (706) 542-4807; E-mail: http://www.cosmic.uga.edu or service@cosmic.uga.edu.

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Reader Forum

Reader Forum is devoted to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a specific technical problem, or an answer to a question that appeared in a recent issue, send your letter to the address below.

We are trying to find an equivalent for Mobil Gargoyle B2 grease, which is no longer in production. It was a calcium grease soap with a drop point of 100°C and penetration 241 (unworked) and 252 (worked). Oil separation at 100°C for 24 hours was 80%. We will use it as a release agent on a wooden former over which acrylic sheets are cast by stretching. Maintaining the smooth texture and transmissibility of the finished acrylic product are key requirements. Thank you.

Prab V. Prabhu, President
IMPEX, Inc.
Tulsa, OK
e-mail: prab@compuserve.com

NASA Tech Briefs *is an invaluable tool to us. Most of our work is in single units, prototypes, and models. We do mostly design work and have used so many different disciplines and fields of science in our work that the only alternative to* NASA Tech Briefs *would be at least eight different specialty trade magazines. The extremely exotic applications and end products we design and create would be difficult to research, even on the Internet, without encountering NASA-developed concepts and technologies.*

Tony Max Nance
Decotech/NANCEtech
Laurinburg, NC

I am searching for materials with the following characteristics and purposes: 1) Inexpensive metals to alter existing vehicles to provide non-resonance of voice through other metals; 2) Acoustic foams and materials for supersonic hearing to prevent associated painful frequencies and sound pressure levels during highway travel; 3) Inexpensive, durable plastics for van conversions; and 4) Impact-resistant, soundproof studio glass.

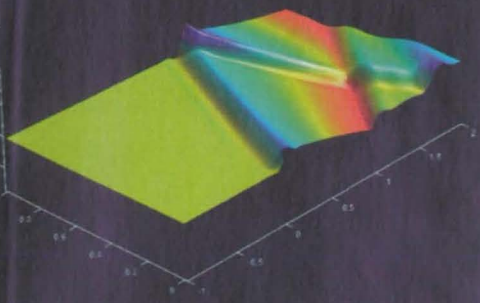
I am a disabled health care consultant, and I need to research these items and how they can block radio waves. Please advise where I can acquire such materials. Thank you.

Rick D. Estes
Tempe, TX

I am trying to find a source of small silicon bronze machine screws (#0, 2, 4). I would appreciate any suggestions on where to locate these screws.

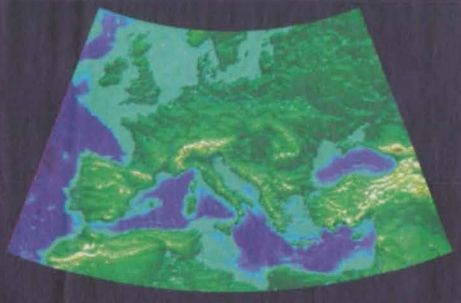
Timothy Lippa
Johns Hopkins University
Baltimore, MD
e-mail: tlippa@jhuvms.hcf.jhu.edu

Post your letters to Reader Forum on-line at: **www.nasatech.com** or send to: Editor, *NASA Tech Briefs*, 317 Madison Ave., New York, NY 10017; Fax: 212-986-7864. Please include your name, company (if applicable), address, and phone number or e-mail address.



Technical Graphics

MATLAB 5 lets you visualize physical phenomena like this shock wave propagating in a fluid.



Mapping

The new MATLAB Mapping Toolbox can be applied to environmental, oceanographic, and defense applications.

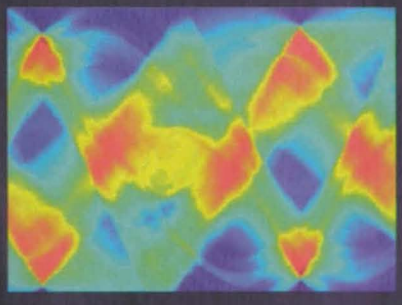


Image Processing

This Radon transform of a spine X-ray illustrates one of the many uses of the Image Processing Toolbox.

Now see what you think.

New MATLAB 5, now with advanced visualization and a complete language for application development.

New Visualization Power

Now you can quickly create more informative and revealing 2-D and 3-D graphics directly in MATLAB 5. Gain insights into complex systems using capabilities like lighting and shading, camera control and texture mapping. Efficient new algorithms make even irregularly-sampled data display faster and easier.

Application Development

A host of language and data management enhancements make algorithm and application development fast and intuitive. We added:

- visual debugger/editor
- function performance profiler
- point-and-click GUI builder
- object-oriented programming

Multidimensional Arrays and Structures

Now the MATLAB matrix computing language supports multidimensional arrays and user-definable multitype data structures. MATLAB 5 includes a full set of functions for manipulating and analyzing multidimensional data, and even visualizing 3-D slices.

New Toolboxes

Companion toolboxes offer application-specific graph types, analysis functions, and interactive interfaces. New and updated toolboxes include:

- NEW Mapping Toolbox
- UPDATE Image Processing Toolbox
- UPDATE Signal Processing Toolbox
- UPDATE Control System Toolbox

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For More Information Circle No. 512

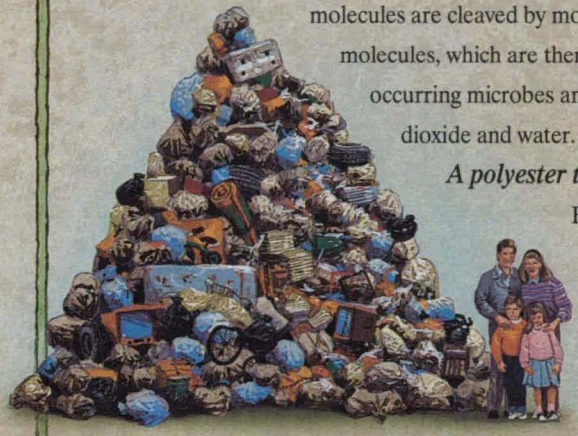
Efforts to develop a truly practical degradable material are reaching fruition. DuPont scientists have created an inexpensive polymer that decomposes without harm to the soil or the environment.

By now, the problems associated with overburdened landfills are widely recognized. Although recycling is the preferred solution, degradable materials can also play an important role. Yet, cost barriers and other issues have consistently blocked their wide-scale adoption in major consumer applications.

To meet this challenge, DuPont scientists have created a new family of highly versatile polymers based on polyethylene terephthalate (PET) technology and known commercially as DuPont Biomax® hydro/biodegradable polyester. Depending on the application, up to

Raised on a diet of plastic cups,

three proprietary aliphatic monomers are incorporated into the polymer. The monomers create weak spots in the polymeric chains, thereby making them susceptible to degradation through hydrolysis. The large polymer molecules are cleaved by moisture into smaller molecules, which are then consumed by naturally occurring microbes and converted to carbon dioxide and water.



The average American family generates 6,488 pounds of trash each year. The availability of products made with degradable polymers would reduce impact on the environment.

A polyester that microbes find tasty.

Biomax® can be recycled, incinerated or landfilled, but is intended mainly for disposal by composting and in-soil degradation. Researchers performed a series of tests to determine environmental impact, including plant germination and seedling emergence, earthworm weight gain and mortality, and microbial population density. In all tests, the materials were found to be harmless to the environment at every stage in the decomposition process. They are virtually undetectable to the unaided eye in about eight weeks.

Because Biomax® is a modified PET polymer, it can be manufactured with existing equipment using existing bulk monomers. This means that it is only marginally more expensive to produce than PET itself. Currently available degradable materials, on the other hand, can cost twice as much.

Degradable fishing line and fishing nets would help alleviate a serious problem for sea mammals who ingest or become entangled in aquatic trash.

snack bags and gum wrappers.

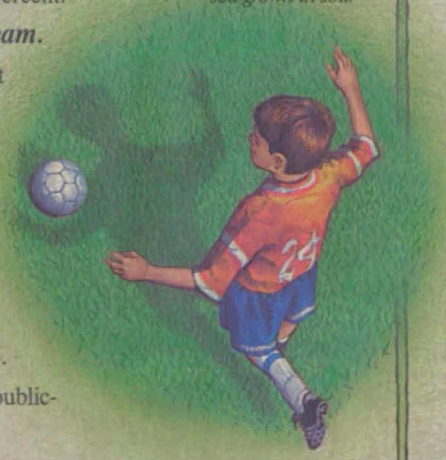
How to make your products disappear. The sheer number of potential applications for Biomax® is immense. Because it can be made into fibers, films or resins, it is suitable for a range of single-use products, including domestic wipes, yard waste bags, the top and back sheets of disposable diapers, blister packs and disposable eating utensils. It can be used to create geotextiles, agricultural films, seed mats, plant pots and bags that cover ripening fruit. It can find application in coated paper products such as disposable plates and cups, aluminized films for food packaging and hot-melt adhesives. It is also suitable for thermoformed packaging, blown bottles and injection-molded objects.

Product properties are diverse and customizable, but are generally tailored to mimic polyethylene or polypropylene. Biomax® is soft, pliable, low in noise and has a good hand. Melting points are high for a degradable material, generally around 200°C, which opens up a range of processing options. It can be formulated to be as low in strength as low-density polyethylene or as high as half the strength of DuPont Mylar® polyester film. Elongation can range from 50 to 500 percent.

Turf grass grown on a mat of degradable DuPont Biomax® weighs one-tenth as much as sod grown in soil.

A world with less trash. Share the dream.

Throughout DuPont's history, many of our most important contributions have only come to market through collaboration with other companies. If the substance of this article leads you to conclude that a development opportunity might exist between your company and DuPont, fax us on company letterhead with an indication of your interests to the attention of: DuPont, Dept. NT, at 302-695-7615. Please limit your correspondence to nonproprietary, public-domain information only.

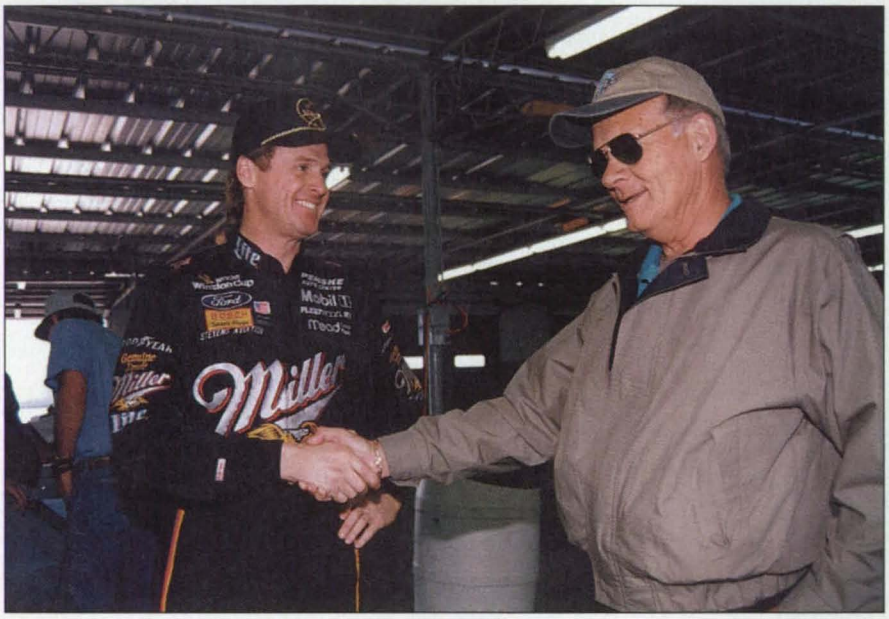


DUPONT

Better things for better living

NASA NEWS BRIEFS

The same insulation material that enables instruments aboard the Hubble Space Telescope to see the ends of the universe may soon help race car drivers. A new company, Bobby Allison Technologies, has been formed to introduce insulating materials manufactured by Energy "Q" International of Fort Worth, TX, into the sport of car racing. The first tests of composite flexible blanket insulation and a radiant barrier were in Rusty Wallace's Ford Thunderbird, with racing legend Bobby Allison one of the lead consultants on the project. The engine compartment and exhaust system were fitted with the material at NASA's Kennedy Space Center (see *NASA Tech Briefs*, Aug. 1996, page 20).



Veteran NASCAR driver Rusty Wallace (left) and former Kennedy Space Center Director Jay Honeycutt meet prior to testing the thermal blanket insulation in Wallace's Ford Thunderbird.

The first vehicle equipped with the new heat-fighting insulation technologies ran in qualifying trials in May at the Busch Grand National Race in Charlotte, NC, in a car driven by Doug Reid, who tested some of the insulation again at a race in Talledega, AL. "For the first time in my racing career, I didn't even break a sweat," said Reid. Instruments showed the temperature at the gas pedal never exceeded 90°F. Formerly, temperatures could exceed 330°F. Johnny Benson's Pennzoil Pontiac, operated by the Bahari Racing Team, was scheduled to use the technology in the NASCAR Daytona 500 in Florida on July 5.

The Chrysler Corporation has picked up on the value of the insulation technologies from space. Chrysler's 1998 Dodge Viper may incorporate a radiant barrier exhaust heat reflector, fabricated by Engineered Thermal Systems of St. Johnsbury, VT.

For more information, contact NASA's Marshall Space Flight Center at 205-544-5419.

A team of three engineers at NASA's Ames Research Center designed a non-toxic fluid to keep ice from building up on airplanes. It is so environmentally safe that it has been referred to as "food grade," since ingredients used in its creation have been approved by the Food and Drug Administration for use in food. When used in bulk, the de-icer poses significantly less of an environmental hazard than chemicals currently in use.

Anti-icing fluids used today can sicken or kill water life, animals, and humans due to ingredients such as ethylene glycol and additives. The new fluid contains propylene glycol that may be food-grade. Worldwide about a half-billion gallons of aircraft de-icing fluid are used annually. Much of it could be replaced by the new non-toxic fluid.

In addition to making flying safer, the fluid also may reduce rust and corrosion on cars and may be applied to runways, bridges, and ships. "You can spray it on your windshield the night before you go to work, and the next morning, the wiper blades will easily push the ice completely off the glass," said Leonard Haslim, an inventor of the fluid.

The anti-icing fluid will grab onto an airplane's surface better than current fluids when a plane is at rest. When the plane takes off, the fluid gets thinner and blows away so the wings are clean. The fluid is neutral—neither an acid nor a base—and is non-conductive. It is being tested by government and industry for aircraft use, and comparison tests will be run against corrosive de-icing salts and other materials. If the tests show the fluid is as good as salt for ice removal, it will be tested on a highway test strip.

For more information, contact NASA Ames at 800-678-6882 or access the NASA Commercial Technology Network web page at: http://nctn.hq.nasa.gov/nctn/

Golfers will be shooting lower scores thanks to a partnership between NASA's Lewis Research Center and the Ben Hogan Company. Engineers from Ben Hogan wanted to measure spin rates of experimental golf balls, so they contacted the Great Lakes Industrial Technology Transfer Center (GLITeC), NASA's Midwest Regional Technology Transfer Center, which put the Ben Hogan engineers in touch with Lewis Research Center's Imaging Technology Center. The Imaging Technology Center has state-of-the-art, high-speed video equipment that can gather high-quality digital video imagery to measure, analyze, and obtain accurate data for various applications.

NASA took seven experimental golf balls, marked them with data analysis control points, hit each ball three times with four golf clubs, and captured images of the balls in flight. The imaging data was archived and analyzed via computer to determine the spin rates and velocities. The results allowed Ben Hogan engineers to improve the spin characteristics of the ball.

"Ten days after a decision had been made to work with NASA, we had results in our hands that translated into a spin optimization for us," said Quint

Representatives from Ben Hogan and NASA Lewis Research Center test experimental golf ball designs.

Dougan, plant manager at Ben Hogan Company. GLITeC and Ben Hogan are working to introduce NASA Lewis technology to other golfing products—a new golf ball is scheduled for market introduction this year.

For more information, contact GLITeC at 216-734-0094.

A NASA Ames computer network tool for airplane manufacturers and the government will provide faster access to information to help shorten aircraft design and test processes by about 25 percent. Called Darwin, the network tool is expected to revolutionize the way airplanes are developed by using wind tunnels linked with computers that send nearly instant test results via a network to geographically separated companies and labs.

The key to Darwin's success is its ability to funnel wind tunnel data into a server computer, and then send knowledge back to researchers within about 30 seconds to five minutes. It is similar to the Internet, but is not open to the public. The system is able to link NASA, the aerospace industry, and academic centers that may be located thousands of miles apart.

Pressure gauges, strain gauges, and other instruments attached to the aircraft models take readings while air blows through wind tunnels during experiments. Data from the model instruments tell aerospace engineers how much lift, drag, and maneuvering performance an airplane model can generate through different flight angles, and at various speeds, altitudes, and conditions.

Aerospace models used in wind tunnel tests often cost more than $1 million each because they must be exactly to scale, and they must be instrumented extensively. Running a large wind tunnel can cost tens of thousands of dollars per hour, so engineers would prefer not to have to return for follow-up tests with modified models.

"Our purpose is to get results and data out of NASA wind tunnels faster. Previously, such knowledge had to be derived by scientists and engineers in the days and months following wind tunnel tests," said Dr. David Korsmeyer, deputy project manager at NASA Ames.

For more information, contact John Bluck of NASA Ames at 415-604-5026 or e-mail: jbluck@mail.arc.nasa.gov

A waterjet coating-removal system developed at NASA's Marshall Space Flight Center to remove thermal protective coatings from the space shuttle solid rocket booster's nonmotor elements is finding more down-to-earth applications in the nation's ship repair and aircraft industries. The first commercial application of the waterjet stripping technology was to clean aircraft gas turbine engine parts. Developed by Pratt & Whitney Waterjet Systems, Inc. in Huntsville, AL, Engine ARMS®—Automated Robotic Maintenance System—sprays water at a pressure of 55,000 psi to quickly remove gaskets, seals, metal- and plasma-sprayed coatings, and more. Engine parts cleaned with the system can range in size from 6-in.-diameter shafts to 120-in.-diameter inlet fan casings. Most airlines have said the technique has paid for itself within two to three years.

Now the technology is being used to remove coatings and encrustations from ships, submarines, and floating drydocks. Challenges facing today's shipyards include both the enormous size of modern ships and the need to contain virtually all of the effluent from the coating-removal process. Waterjet Systems meets these challenges with its Ship ARMS® product. It is equipped with a modular water reclamation unit for filtration and recirculation, and the only waste product is the solid coating residue it removes from hulls and docks. A nozzle shroud and vacuum ports on the device remove the process effluent as the coatings are stripped, leaving the surface dry and rust-free. Stripping time is reduced, meaning less time in drydock, a boon for both the ship's owner and the drydock's operators. There is less cleanup, with a 50:1 reduction in solid waste compared to dry abrasive blasting. Recoating can begin immediately. The system has been successfully demonstrated by the U.S. Navy on such vessels as the aircraft carrier U.S.S. Nimitz.

For further information, contact either the Technology Transfer Office at NASA's Marshall Space Flight Center (1-800-USA-NASA), or Waterjet Systems, 6000 Technology Dr., Building C6, Huntsville, AL 35805-1955, or call (205) 721-2728/1-800-239-2773.

TECHNOLOGY 2007

Technology 2007 will be held for the first time in the northeast from September 22-24 at the Hynes Convention Center in Boston. The Engineering Innovation Show, Technology 2007 will feature commercially promising inventions and processes developed by the country's leading government and industry technologists. Here are some of those innovations.

NEXT-GENERATION INTERNET

As part of Tuesday's Plenary Session, Christine Falsetti, Next Generation Internet (NGI) Project Manager at NASA's Ames Research Center in Mountain View, CA, will tell attendees how the Next Generation Internet initiative could by 2002 result in information flowing a million times faster than today's home computer modems, and 1,000 times faster than a current standard T1 business computer line.

NASA Ames is the lead institution for the agency's $30 million portion of the three-year, $300 million federal project to develop the NGI. Other agencies participating in the project include the National Science Foundation, the Defense Advanced Research Projects Agency, the Department of Energy, the National Institutes of Health, and the National Institute of Standards and Technology. Beginning in October, Ames will lead NASA in the project, which will involve about 30 full-time dedicated workers.

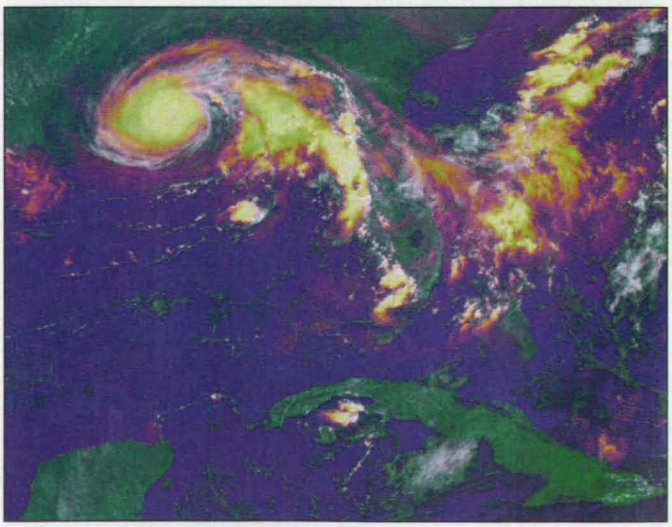
"We want to guarantee levels of service that will eliminate slowdowns and network stagnation that users sometimes have to endure now while waiting for Internet images, movies, and other services," said Falsetti. NASA and other federal agencies will conduct R&D that could interconnect "core sites" with high-speed lines late this year. "Then we'll connect to GigaPOPs across the country," she said. A GigaPOP is a regional group of core organizations that will connect separate computer network systems by high-speed communications lines. Falsetti explained that "an example of a GigaPOP in the greater San Francisco Bay area would be the high-speed linking of NASA Ames, Lawrence Livermore Laboratory, the University of California-San Francisco, and Stanford University." (A POP is a point of presence, and Giga stands for a billion computer bits.)

The federal government plans to hook up about 100 universities, research labs, and other institutions at 100 times the speed attainable today. NASA now has five research sites connected at 155 megabits, or 155,000,000 bits per second. Falsetti added that over time, GigaPOP interconnects will be improved so that they can transmit data at faster rates. Medical use of NGI is expected to be significant. "You'll go to your local doctor, and he will be able to consult with specialists across the globe," said Falsetti. "That will mean you can get access to the best medical expertise in the world."

Initially, NGI will be a national network, but NASA is looking for international partners to meet its global needs. "We are building a research network," Falsetti explained. "Technical advances will spin-off from NGI, and industry will put improvements into the 'old' Internet to make it work better and faster."

VISUALIZING HYPERIMAGE DATASETS

Fritz Hasler, research meteorologist at NASA's Goddard Laboratory for Atmospheres in Greenbelt, MD, will



A scientific visualization approach developed at NASA Goddard enables processing of HyperImage datasets and 3D model results. This image is a visualization of Hurricane Danny obtained on July 19, 1997 at 10:00 am CST in the Gulf of Mexico near Alabama.

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demonstrate new methods for visualizing immense HyperImage remote sensing datasets and three-dimensional numerical model results. "We call the data from many new Earth-sensing satellites HyperImage datasets because they have such high resolution in the spectral, temporal, spatial, and dynamic range domains," Hasler pointed out.

The traditional numerical spreadsheet paradigm has been extended to develop a scientific visualization approach for processing HyperImage datasets and 3D model results interactively. The advantages of such extension to multiple sets of images and organizing image processing is demonstrated using the Interactive Image SpreadSheet (IISS). Illustrations will include simultaneous satellite and aircraft radar images of Hurricane Luis, lightning detector data merged with GOES image sequences, SSM/I microwave spectrum animations of daily North Pole icepack data, and synchronized manipulation of multiple 3D numerical model views.

PROJECTS TARGET REUSE AND RECYCLING

The Convergent Spray Technology process, initially developed by USBI Company to apply highly-filled, thermal protection coatings to the space shuttle solid rocket boosters, has been used to deposit a lightweight, highly-filled roofing coating on low-sloped commercial roofs. A partnership among NASA, the Environmental Protection Agency, and USBI was formed to develop, demonstrate, and evaluate a technology that uses the solventless Convergent Spray Technology.

Although levels of Volatile Organic Compound (VOC) emissions from industrial roof coating and painting operations have been reduced in recent years, the project is an effort to further reduce VOC emission levels and demonstrate the use of reclaimed tire rubber as a filler material in roof coating. Different materials and coatings were evaluated and tested before the final selection was used to coat the roofs of two small buildings at NASA's Marshall Space Flight Center in Alabama.

In another project, Rajiv Kohli of RKAssociates of Columbus, OH, has developed a simple decontamination system for free release and recycling of metals. There is a large inventory of potentially valuable and recyclable metals such as nickel, aluminum, copper, and lead. Under current regulations, this inventory is sufficiently contaminated to require disposal as either radioactive mixed waste or hazardous waste. In the U.S., disposal of contaminated lead, in particular, is almost impossible due to its highly toxic nature, specific disposal regulations, and a lack of available disposal sites.

Most of the inventory of these metals is surface-contaminated. An optimized system, based on a patented dilute formic acid treatment process, was developed for decontamination to free release levels of the contaminated metals inventory. The system incorporates a newly-developed precision metal sampling technique to measure the effectiveness of the decontamination process.

The benefits of the system include remote handling and process operations, minimizing personnel exposure; use of very dilute solutions (0.5 to 1%); low toxicity of the acids and the additives to the acid solution; and simple equipment and process control to keep costs low.

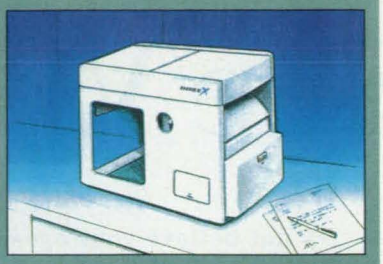
ASSISTIVE TECHNOLOGY BRIDGES THE GAP

A coalition of federal agencies and not-for-profit organizations has joined to create a three-way partnership among federal laboratories engaged in scientific and engineering research for agencies such as the Departments of Energy and Defense; other federal labs engaged in assistive technology research to benefit persons with disabilities; and consumers who use assistive and rehabilitative technology products and services.

A special session will answer the question: "What is assistive technology, and how do people with disabilities benefit from it?" The relationship between technology developed at many of the federal labs and the potential and real relationship to the technology-related gaps and needs of the approximately 49 million individuals with disabilities in the U.S. will be addressed. Ways in which government and private industry are promoting technology transfer in this area will be

ON DISPLAY

New England Technology Showcase Booth 4

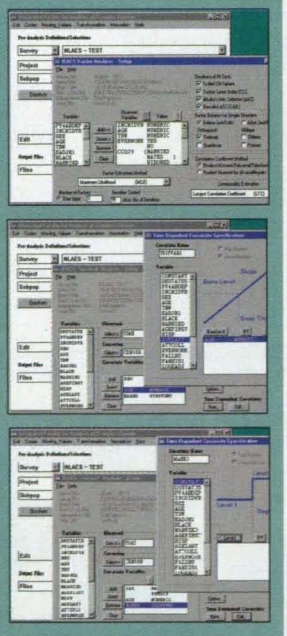


Imagex Technologies, Framingham, MA, will display a prototype decopier, which removes ink from photocopied and laser-printed paper for reuse, thereby reducing the cost and waste of paper and paper products. The company designs, develops, manufactures, and markets proprietary office products and machine technologies that allow businesses to reuse discarded paper and related products.

For More Information Circle No. 775

ON DISPLAY

SBIR Booth 5



IFACS version 2.0 software for statistical analysis of complex survey data will be on display by Analysis and Simulation, Buffalo, NY. The program features expanded capabilities for conducting multivariate data analyses under complex sampling designs. Hierarchically organized data definition procedures enable specification/retention of survey data sets, response fields focus within each survey, and pre-analysis data processing for definition/evaluation of recoded/transformed variables. Input survey data sets may be in ASCII or SAS Transport Data Set formats. It is available for Windows 95/NT, and UNIX operating systems.

For More Information Circle No. 776

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For More Information Circle No. 516

discussed, as well as authorizing legislation related to technology transfer and disabilities.

To date, the transfer of many products from labs to the disabled community has occurred because of a few dedicated "champions." This special session will help foster a better understanding on the part of federal labs of the needs of persons with disabilities.

ENSURING STRUCTURAL STRENGTH

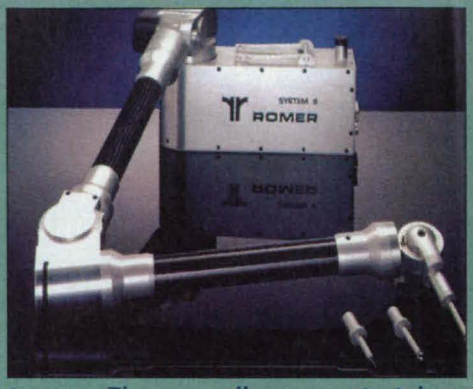
Dimensional measurements often are essential to the function and performance of a structure. Deviations from permissible tolerances can impede operation and result in premature failure of the structure. It becomes imperative, then, to check and validate the dimensional accuracy of the structure. There are many state-of-the-art angle, displacement, and deflection measuring instruments based on visual, optical, electromechanical, gravitational, and other physical principles. However, these devices usually require line-of-sight accessibility to the structure.

An eddy current sensing assembly developed by Dr. E. James Chern of NASA Goddard Space Flight Center will enable indirect measurement of deflections. Eddy currents are induced in an electrically conductive object by the varying electromagnetic field of a sensing coil. An example of an eddy current deflection measuring application is a horizontal tube centerline deflection and radius of curvature measurements. A specially designed eddy current sensing assembly is integrated with a mechanical delivery system. Potential applications include buildings, bridges, and other infrastructures.

For more information, access the Technology 2007 home page at www.abptuf.org/T2007 or call 212-490-3999.

ON DISPLAY

Booth 707



Portable articulating arm CMM systems will be displayed by ROMER, Carlsbad, CA. The systems feature six-axis articulation, and up to a 20 x 20 foot range. The arms allow users to take accurate measurements from any direction in any location, and are mountable in any orientation, including upside-down. Starting at 19 lbs., they feature unlimited rotation of joints and built-in software. The systems use a variety of probes and provide accuracy to ±0.001 inch.

For More Information Circle No. 777

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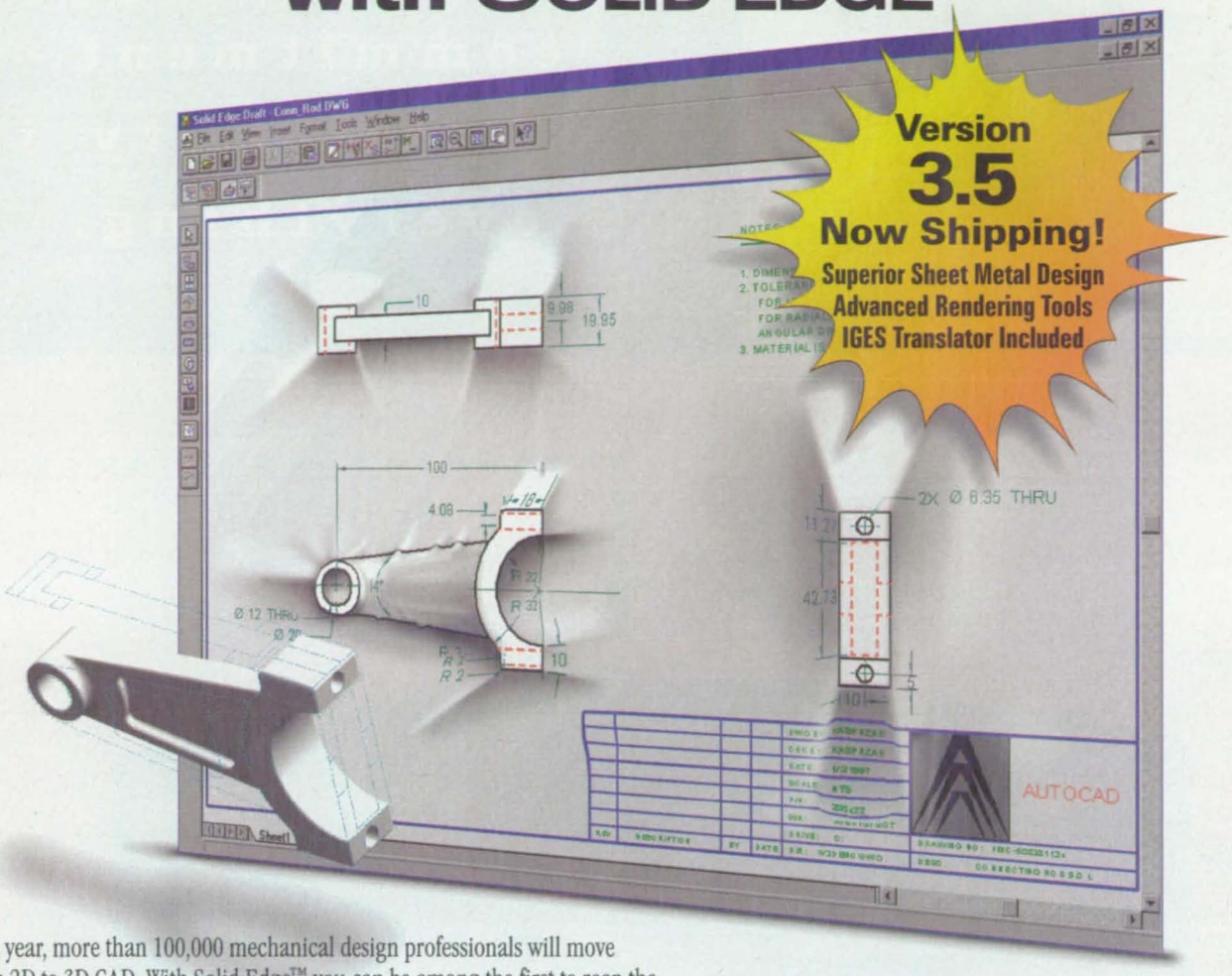

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[1] *Computer Aided Design Report*, Vol. 16, No. 6, June 1996

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Digital Image Storage

DTF HALF INCH TAPE DRIVE

Our next generation DTF high performance computer peripheral tape drive is rich in family heritage, based on Sony's highly successful Digital Betacam® professional recording technology. The GY-2120 (pictured here) features a sustained transfer rate of 12 MB per second (up to 20 MB per second with compression) and storage capacity of up to 108 GB compressed on a single cassette. It has the ability to backup 100 GB of data in approximately an hour and a half, and is already setting the standard for high performance and reliability in a SCSI attached tape storage peripheral. It's also compatible with the PetaSite Mass Storage Library.

Automated Tape Libraries for Mass Storage

Remote Sensing

For More Information Circle No. 542

SONY

Commercialization Opportunities

Optical Monitoring of Deflections of Compressor Blades

A compact system remotely monitors vibrational modes and static deflections of compressor blades, especially in aircraft engines. Near-real-time measurements of the deflections and tip clearances of compressor blades can be determined with timing resolution of 5 ns.
(See page 49.)

Improved Multilayer Optical Memory System

A proposed optoelectronic memory system differs from previous such systems in readout optics, method of identification of layers, and compositions of the layers. These differences promise to improve reliability and precision of optical memory systems in data storage and readout.
(See page 49.)

Photonic Processing of Multigigahertz Signals

Photonic technology is making its way into advanced communication systems operating at frequencies of about 1 to 300 GHz. It exploits the advantages of transmission via fiber optics, which feature light weight, low loss, compactness, and large bandwidth, versus transmission of signals over metallic waveguides.
(See page 50.)

Deicing-Fluid and Ice-Thickness Monitor for Aircraft

In flight, this system warns of ice formation on aircraft surfaces in ample time for pilots to make corrections before it becomes dangerous to fly. On the ground, the system determines when and to what extent aircraft deicing is needed. This prevents excessive deicing, which reduces pollution around airports.
(See page 54.)

Laser Extensometer for Noncontact Measurement of Strain

This instrument measures strains during tensile and fatigue tests at temperatures up to 2,000 °F (1,100 °C). It is not necessary to treat the surface of the specimens nor to place the instrument in a hot test environment.
(See page 58.)

Covalent Cross-Linking for Strengthening Composite Materials

In this proposed process, fibers would be made "hairy" by chemical attachment of oligomers. The oligomers would form covalent bonds and result in stronger matrix/fiber structures.
(See page 62.)

Polymeric Electrolyte Membrane Materials for Fuel Cells

The advantages of this solid electrolyte are low cost, thermal stability, low methanol permeability, and high proton conductivity.
(See page 64.)

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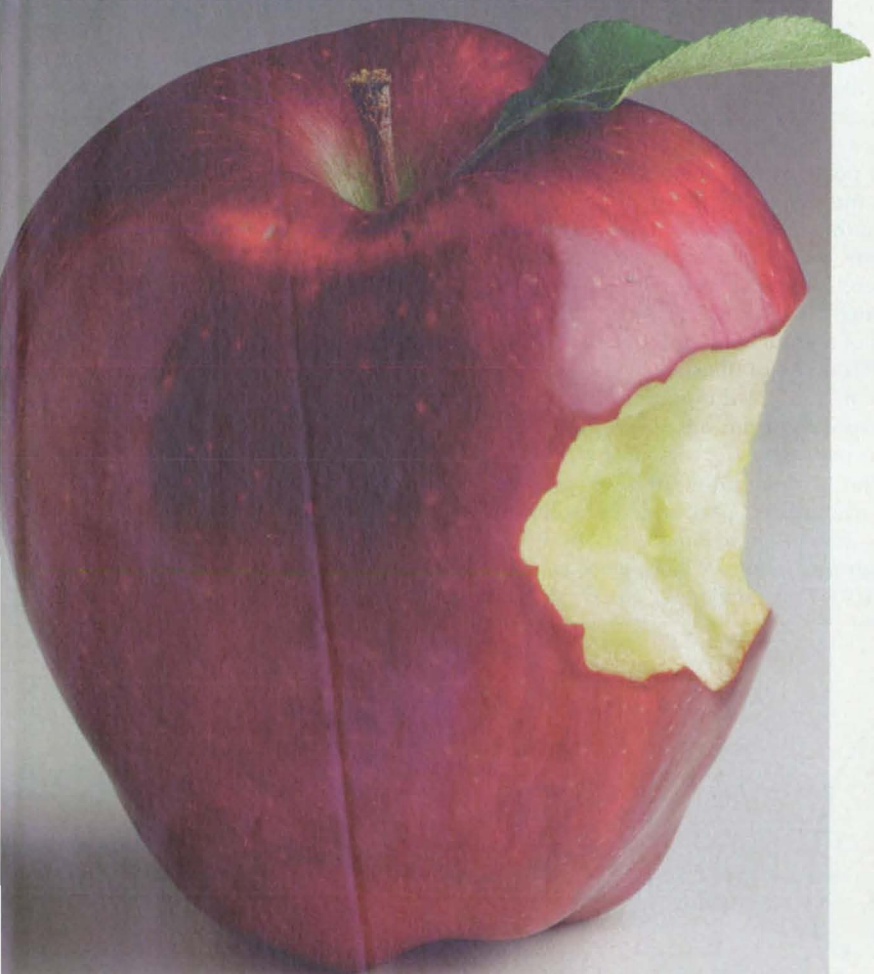

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For More Information Circle No. 518

Parallel-Processing Program for Assimilation of Weather Data

Observations can be used to refine forecasts in real time.

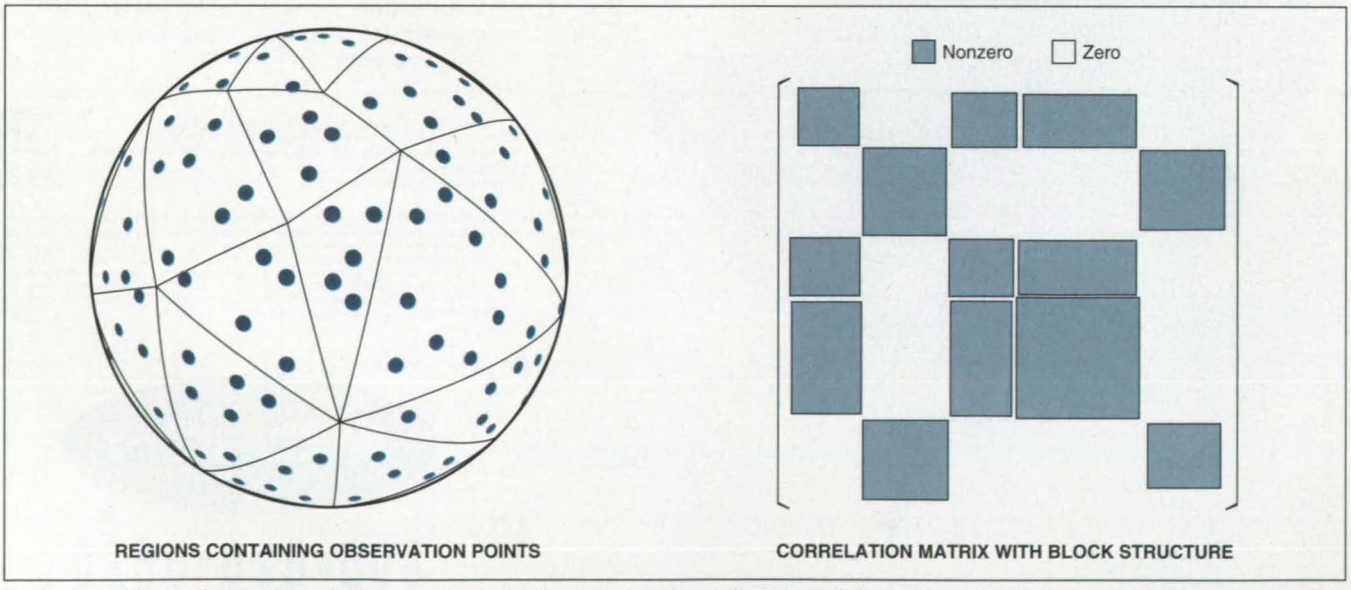
NASA's Jet Propulsion Laboratory, Pasadena, California

The parallel Physical-space Statistical Analysis System (PSAS) computer program was developed to exploit parallel processing on hundreds or even thousands of computer nodes to assimilate weather data more than 100 times as fast as on a conventional supercomputer, such as a Cray C90 (or equivalent). For example, the assimilation of data from a set of 80,000 observations at various locations around the Earth takes about 5 hours of central-processing-unit time on a single-head Cray C90 (or equivalent) computer, estimated by the Data Assimilation Office at Goddard Space Flight Center, who first developed the C90 version of the PSAS program. By use of parallel PSAS in a 512-node Paragon (or equivalent) computer, the same data can be assimilated in a total time of only 158 seconds; this includes time spent reading data from and writing data onto magnetic disks. Thus, the performance of parallel PSAS greatly exceeds the requirement for assimilation of weather data in real time in the sense that the total processing time for assimilation is much less than the 6-hour standard interval between meteorological observations. Indeed, the speed achievable with PSAS is great enough to enable more than 100 assimilations per day, making it practical to reevaluate weather data from past years.

"Assimilation" as used here denotes a fusion of (1) data from observations at a given time with (2) forecast data for the same time produced by another computer program. A typical forecast program produces data on a regular grid with intervals of 2° in latitude, 2.5° in longitude, and between 14 and 22 altitudes. The observational data are obtained from many sources, some of which (e.g., weather balloons) are moving from this six-hour interval to the next six-hour interval, and most or all of which may not be located at regular grid points. In the assimilation process, (1) the forecast data are interpolated from the regular grid to the observation points, (2) the observational data are combined with the forecast data through a statistical process similar to that of a Kalman filter to obtain an optimal estimate of the state of the weather system, and (3) the optimal estimate is interpolated from the observation locations back onto the regular grid.

The computation-intensive part of the assimilation process is the solution of a system of linear equations in N unknowns, where N is typically as large as 10^5. The challenge posed by the assimilation problem lies in the size of the $N \times N$ matrix of this system of equations. To store the entire matrix, one would need 10GB (in single precision) or 20GB (in double precision) of memory, exceeding the capacity of any currently available sequential computer. However, this requirement does not exceed the total distributed memory (16GB) of the 512-node parallel processor. Moreover, the huge number of floating-point computations for solving the equations can be distributed to individual nodes, reducing the solution time dramatically. The problem then becomes one of how to distribute parts of the matrix to the nodes.

In an approximation based on a cutoff in correlations of observations made more than 6,000 km apart on the surface of the Earth, 74 percent of the matrix elements can be set to zero. This approximation can be utilized and modified in such a way as to impose a structure on the matrix: By use of a concurrent partitioning algorithm that adapts readily to different sets of observations, the surface of the Earth is divided into regions that contain approximately equal numbers of observations. The correlation cutoff is then enforced at the region level (see figure); that is,



The **Surface of the Earth Is Partitioned** into regions that contain approximately equal numbers of observation points. Correlations in regions centered more than 6,000 km apart are set to zero, resulting in a matrix with a block structure.

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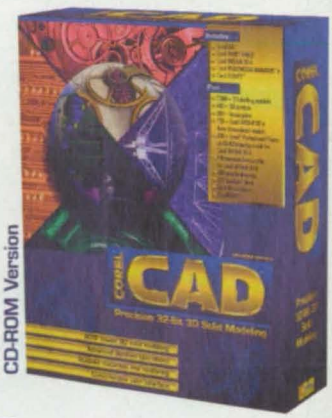

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all observations in one region are treated as either correlated to all observations in another region or else not correlated to any observations in the other region, depending on whether the centers of the two regions are closer or farther than 6,000 km. This modified version of the correlation cutoff partitions the matrix into a block structure, in which the elements in 74 percent of the blocks are zero.

This modification leads to a correct and consistent approximate solution that differs from the solution for the nonregionalized version by a root-mean-square error of 1 to 2 percent. The big advantage gained from the block pattern is the ability to use a highly efficient matrix-vector multiplication routine that is designed for block matrices and that is an order of magnitude faster than are conventional techniques designed for sparse matrices.

This work was done by Hong Q. Ding and Robert D. Ferraro of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 102*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*
NPO-19936

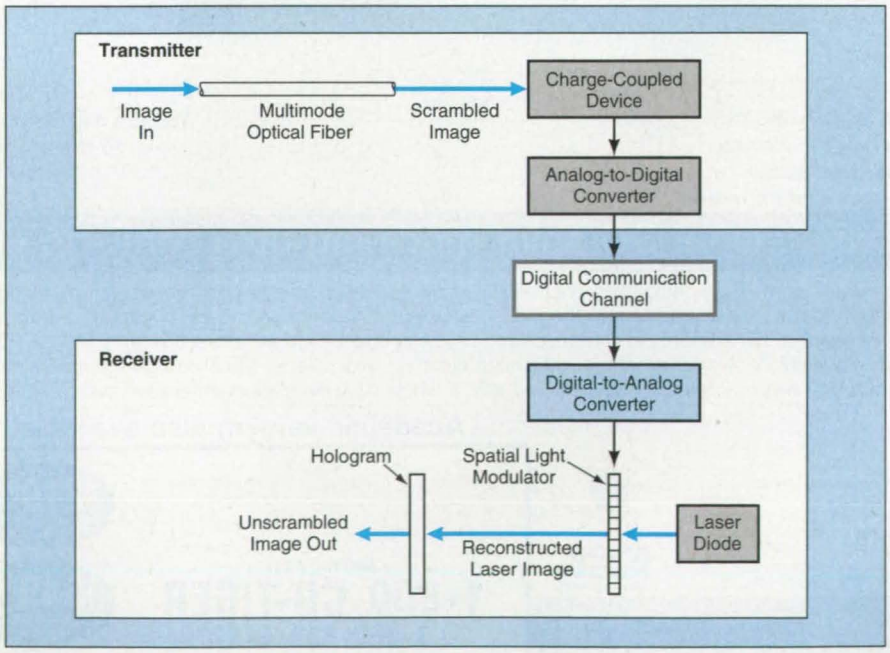
Optical Encryption of Images for Data-Transmission Security

Phase-scrambling in optical fibers would provide the equivalent of long encryption keys.

NASA's Jet Propulsion Laboratory, Pasadena, California

In a proposed scheme for enhancing privacy in the digital transmission of images, each image would be encrypted optically (while still in its analog form) before digitization and transmission. In the receiver, the digital image data would be used to reconstruct the encrypted analog image, and this image would be decrypted optically. The analog encryption and decryption could be performed instead of, or in addition to, digital encryption and decryption. Of course, one of the advantages of optical analog encryption and decryption would be the inherent high-speed, massively parallel nature of optical processing.

The analog encryption would be initiated by launching a beam of light containing the image information into a multimode optical fiber (see figure). During propagation along the fiber, the phases of the wavefronts carrying the image information would become scrambled. Consider the practicality of measuring all the wavelength, phase, amplitude, and polarization compo-



The **Input Image Would Be Scrambled Optically** in the multimode optical fiber prior to transmission. After reconstruction of the scrambled image in the receiver, the image would be unscrambled optically by use of a hologram previously made from the optical fiber.

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nents of the light emerging from the output end of the optical fiber, computing all the waveguide modes that can propagate in the multimode optical fiber, and computing the corresponding coefficients needed to unscramble the image information in the emerging light. It is not practical to do these things, but even if it were, the large number of the aforementioned components, modes, and coefficients would place digital computational unscrambling beyond the reach of current technology; the security of encryption would be comparable to that of digital encryption with a key of length $>10^6$, and possibly several orders of magnitude beyond that. In contrast, digital encryption keys in current use typically have lengths of 100 or less.

The only practical way to decrypt the encrypted analog image would be to reverse the phase-scrambling process optically. To make this possible, a beam of light carrying no spatial image information would be sent through the fiber and the emerging beam would be used to make a hologram that would embody the phase-scrambling information. Thereafter, the hologram would be placed in the path of the beam of light containing the reconstructed scrambled image to reverse the phase-scrambling process and thus recover the original image. It should be easy to construct optical-fiber/hologram scrambler/descrambler pairs such that each pair provided the equivalent of a unique, highly secure code.

This work was done by Deborah L. Jackson and Chien C. Chen of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category,* ***or circle no. 104*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

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Refer to NPO-19574, volume and number of this NASA Tech Briefs *issue, and the page number.*

Improved Noncontact Technique for Measuring Volumes of Drops

Electrostatic levitation offers advantages over electromagnetic levitation.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved noncontact technique provides accurate measurements of the volumes of small (diameter 2 to 3 mm) liquid and solid material samples at high temperatures. The technique is suitable for determining the densities and coefficients of thermal expansion of metals, semiconductors, and other materials that are required to be kept pure during measurement. In this technique, a sample is observed and heated while it is levitated electrostatically in a high vacuum (see Figure 1). The observation includes recording a video image of the sample. The image is then digitized, and the digital image data are processed to determine the volume of the sample.

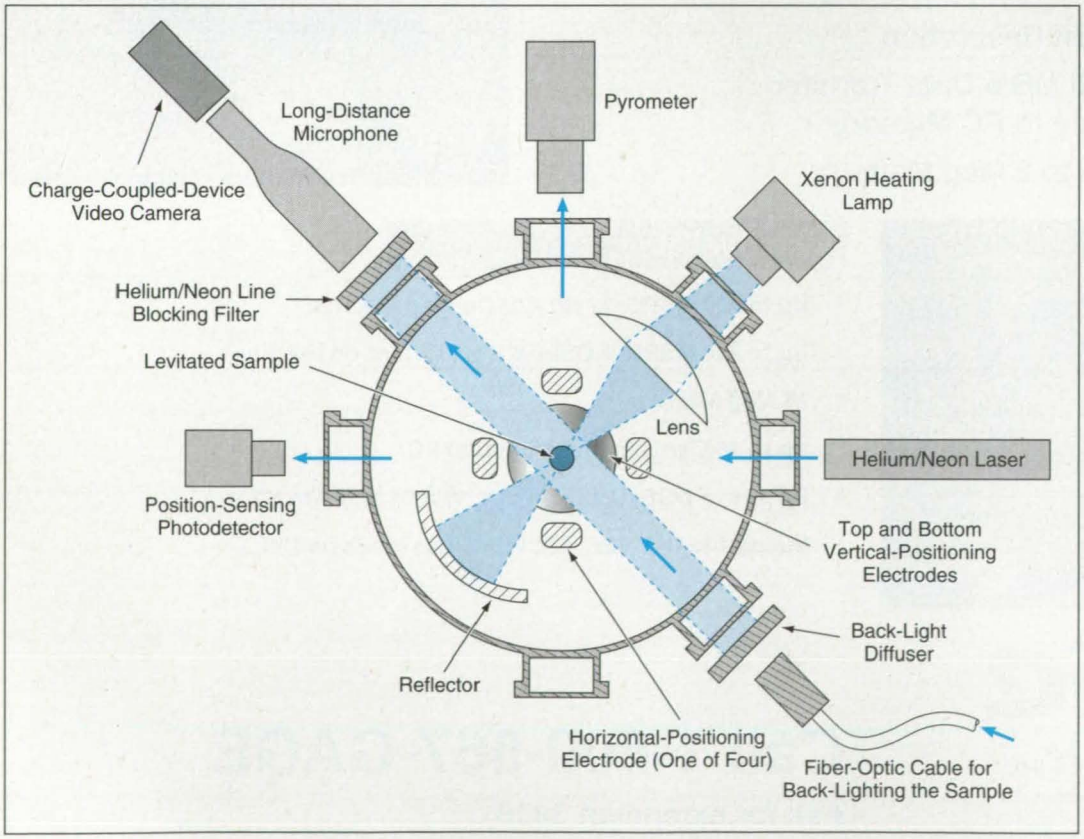

Figure 1. A **High-Temperature Electrostatic Levitator** and associated instrumentation are used to levitate the sample at high temperature and measure its volume. The volume of the sample is computed from the video image.

The most closely related noncontact technique used heretofore to measure the volumes of small samples involves photographing samples that are levitated electromagnetically. Electromagnetic levitation imposes several limitations on the desired measurement capability: (1) In a liquid sample, stirring caused by the eddy currents tends to distort the shape of the sample severely, so that the measurement of the volume of the sample becomes complicated and inaccurate. (2) The sample material must either be inherently electrically conductive or else be made electrically con-

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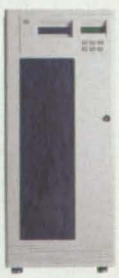
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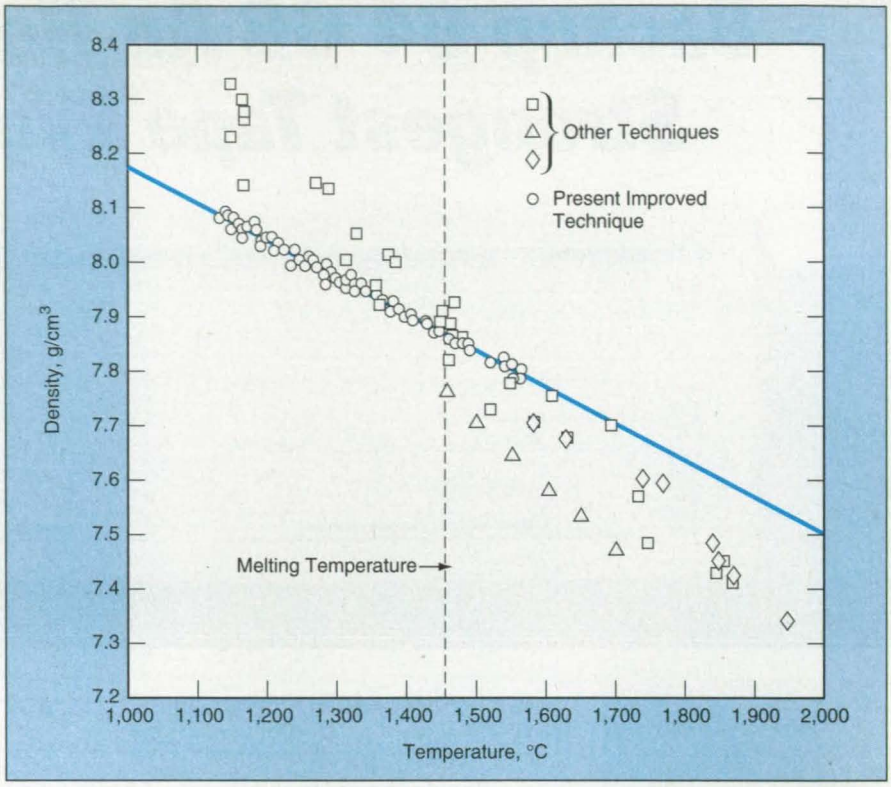

Figure 2. The **Density of Nickel vs. Temperature** around the melting temperature was determined by the technique described in the text, and is shown here in comparison with similar determinations by other techniques.

ductive by addition of electrically conductive material, which constitutes an undesired impurity; therefore, almost all nonconductors and semiconductors are excluded from measurement. (3) The electromagnetic-levitation apparatus includes coils wound closely around the sample, making it difficult to acquire an image of the sample. (4) Heating and levitation are strongly coupled, so that it is very difficult to measure the volume of a material at a low temperature. The electrostatic levitation technique overcomes all of these disadvantages.

In the improved technique, the position of the sample is controlled actively, and can be maintained stable within 10 μm. The configuration of the electrostatic-levitation electrodes and of the resulting electric field is such as to induce the sample to stay axisymmetric when it is in liquid form, and the video camera views the sample along a horizontal line through the vertical axis of symmetry; therefore, only a single video image provides all the information needed to compute the volume of the sample.

The digitized image data are processed by algorithms similar to those used to analyze the shapes of pendant drops to determine their surface tensions. First, an edge-detection algorithm generates the coordinates of about 400 edge points. These coordinates are then refined in a process that involves analysis of gradients of image intensity in the vicinities of these points. Next, a least-squares best fit is made between the refined edge coordinates and a sixth-order series of axisymmetric spherical harmonics. Then the volume (V) is computed straightforwardly from

$$V = (2\pi/3)\int_0^{\pi}\left[R(\theta)\right]^3 \sin\theta\, d\theta$$

where θ denotes the polar angle and $R(\theta)$ denotes the local radius as expressed by the finite series.

If the observation and the computation of volume of a given sample is repeated for a sequence of temperatures, then the coefficient of thermal expansion of the sample material can be computed from the measured volumes and temperatures. If mass of the sample is known, then its density as a function of temperature can also be determined. The technique has been demonstrated on specimens of nickel at temperatures above and below the melting temperature (see Figure 2).

This work was done by Sang K. Chung, David Thiessen, and Won-Kyu Rhim of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 127*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

NPO-19779

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For More Information Circle No. 521

Designing a Spacecraft Data-Communication System

NASA's Jet Propulsion Laboratory, Pasadena, California

A computer program gives preliminary estimates that are useful for designing the spacecraft end of a radio-communication link for transmitting digital data from low orbit around the Earth to a ground station. [It is related to another program described in "Computing Supportable Bit Rates in Radio Communications" (NPO-20039), *NASA Tech Briefs*, Vol. 21, No. 5 (May 1997), page 50.] The major overall functions of this program are to generate a link budget quickly (a systematic table of gains and losses of the link) and to give approximate values of parameters of a design to satisfy the data-communication requirements. Like the program described in the cited prior article, this program is based partly on established equations for relationships among radiated power, various link margins, gains, losses, modulation index, data rate, distance, antenna dimensions, frequency, receiver noise temperature, and other relevant parameters. Additional factors that are taken into account in this program are the duration of visibility of the spacecraft from the ground station for the orbit in question, the time taken by the ground station to acquire the spacecraft carrier signal, and whether the spacecraft antenna is aimed toward the ground station or toward the nadir. Like the other program, this program is written in the Excel 5.0 software system.

This program was written by Anil Kantak and Faiza Lansing of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Computer Software category,* ***or circle no. 108*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

NPO-19997

Software for Processing SAR Data From the Magellan Project

This software is superior to previous Magellan software that performed similar functions.

NASA's Jet Propulsion Laboratory, Pasadena, California

MGN USP is a computer program for utilizing synthetic-aperture-radar (SAR) data from the Magellan project, which explored the hidden surface of the cloud-covered planet Venus. The "USP" part of the name of this program signifies "UNIX-based SAR Processor." The major functions of the program are reading the experimental data record (EDR) from tape or disk, processing the raw data, and converting them to image data in a format called "Full-Resolution Basic Image Data Record" (F-BIDR).

MGN USP is superior to a previous Magellan-SAR-data-processing program in that it achieves higher precision in the areas of range-migration compensation, Doppler compensation, azimuth-interpolation Kaiser weights, radiometric compensation, and geometric rectification. MGN USP also features provisions for an improved multilook overlay.

MGN USP is written in FORTRAN 77 and C language for a SunOS or Solaris computer workstation (SPARCserver 10, SPARC 670MP, or SPARC 690MP) with 128MB of memory, 1.3GB of disk space, and a nine-track tape drive or an 8-mm tape drive with SCSI interface. The standard distribution medium for MGN USP is one 4-mm DAT in UNIX tar format. MGN USP is also available on 8-mm or nine-track tape by request. MGN USP was released to COSMIC in 1994 and is a copyrighted work with all copyright vested in NASA.

This program was written by M. Jin, L. Chen, and A. Chu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Computer Software category,* ***or circle no. 115*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

NPO-19501

Air-Sampling System Measures Dew Point in a Wind Tunnel

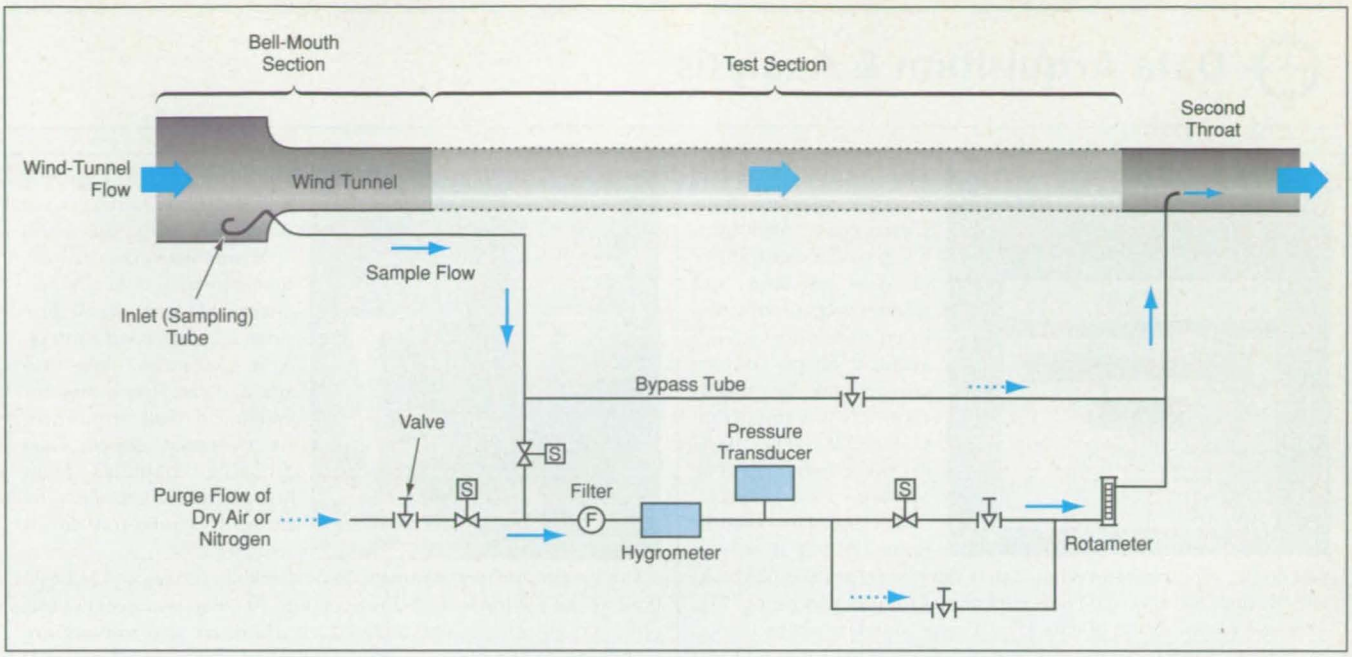
This system gives accurate readings in real time.

Lewis Research Center, Cleveland, Ohio

An improved instrumentation system measures the dew point of air flowing in a supersonic wind tunnel. This system was developed to replace a trouble-prone instrument that had to be operated manually in a trial-and-error procedure. Because the procedure took several minutes to acquire each reading, the readings could not be relied upon to keep up with changing flow conditions, and the cost of tunnel drive power expended unproductively quickly mounted. Other instruments that were tested in an effort to replace that instrument have exhibited various combinations of slow response, erratic readings, and high susceptibility to contamination. In contrast, the present system has been found to constitute a high-response, accurate, dependable instrument that provides nearly-real-time dew-point readings under wind-tunnel operating conditions.

The main sensory component of the present system is a commercial hygrometer with a proprietary moisture detector built on a small silicon chip and with closed-loop temperature control that compensates for the effect of ambient temperature from –40 to +113 °F (–40 to +45 °C). The hygrometer operates satisfactorily at flow rates from 50 to 1,500 cm^3/min or in static conditions at pressures from 0 to 4,000 psig (gauge pressures from 0 to 28 MPa). The hygrometer responds to a step change in moisture in less than 1 minute, with a sensitivity characterized by a change in dew point of 0.002 °F (≈0.001 °C). The range of the hygrometer is –76 °F to +32 °F (–60 to 0 °C) with an accuracy of ±3 °C.

The hygrometer is installed in a wind-tunnel air-sampling system, as indicated schematically in the figure. A pressure transducer is located immediately down-



A **Sample Flow of Air** is extracted from a supersonic wind tunnel for measurement of its dew point. This system operates over the entire pressure range of the wind tunnel [2 to 45 psia (absolute pressure of 14 to 310 kPa)]. There is no need for a vacuum pump to provide the sample flow because this flow is driven by the pressure drop along the test section of the wind tunnel.

stream of the hygrometer. The rate of flow through the hygrometer is monitored by use of a rotameter. A bypass tube makes it possible to increase the sample flow without incurring excessive flow through the hygrometer.

Before the wind tunnel begins to operate, the sampling system and hygrometer are purged with dry air or nitrogen. Once the wind-tunnel compressor has reached operating speed and an air dryer that is part of the wind-tunnel equipment has begun to function, solenoid valves are actuated to (1) switch off the purge flow, (2) connect the upstream end of the hygrometer plumbing to an inlet tube that samples the air in a bell-mouth section upstream from the test section of the wind tunnel, and (3) connect the downstream end of the hygrometer plumbing to an outlet tube that ends in a rearward-facing port at a point downstream inside the wind tunnel downstream of the test section. Thus, the sampling system utilizes the pressure drop along the test section to obtain the sample flow.

The instrumentation system includes an in situ calibration system (omitted from the figure for the sake of clarity) built around a commercial dew-point generator that provides a wide range of stable dew-point conditions. The calibration dew points are measured by use of a chilled-mirror hygrometer, which serves as a transfer standard provided by a calibration laboratory.

This work was done by Philip Z. Blumenthal of NYMA, Inc., for **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 172*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16443.

The CY-DDR **digital data recorder interface** from Cybernetics, Yorktown, VA, provides fast transfer of data to tape and enables users to write digitized data streams from analog-to-digital converters or other instrument recorders to Cybernetics' CY-9000LP DTF tape drive at speeds of up to 36 MB/sec.

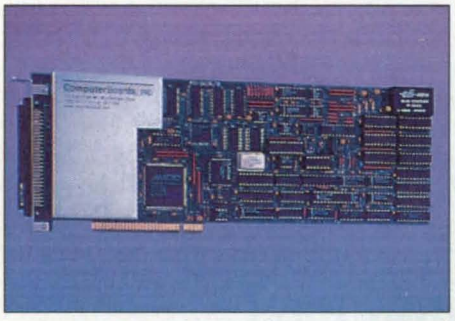
The interface features up to 128 MB of variable rate buffer, supports bi-directional data flow for record and playback, and provides fast access to collected samples for post-processing. The drive can record 42 GB of data to each tape, and data can be striped to multiple drives for high-speed samples or cascaded back and forth for long-duration data collection.

For More Information Circle No. 743

Lockheed Martin Telemetry & Instrumentation, San Diego, CA, offers the ADAS 5000 **automated data acquisition system,** a remotely programmable system that provides signal conditioning, A/D conversion, data storage, and data distribution for end-to-end data acquisition. Its Universal Signal Conditioning Amplifier plugs into any transducer and automatically configures to its requirements.

The system provides automatic limit checking, continuous self-calibration and self-test, system throughput to 16 million samples per second, and an open system architecture. Hardware and software are included for system setup, control, calibration, processing, recording, and display.

For More Information Circle No. 738



ComputerBoards, Mansfield, MA, offers the PCI-DAS1602/16 high-speed, analog I/O **data acquisition board** for the PCI bus. It provides 16-bit A/D and D/A resolutions with 200 kHz sampling rates, and offers 16 single-ended or eight fully differential analog inputs, as well as two channels of 16-bit analog output supporting update rates to 100 kHz.

A variety of trigger and timing options are available, including analog triggering with pre- and post-trigger sampling. A 512-sample FIFO buffer and burst-mode scan sequence also are provided. The board comes with the InstaCal™ installation, calibration, and test software.

For More Information Circle No. 742

IOtech, Cleveland, OH, has introduced the ChartScan/1400™ **data recorder** with ChartView™ software that uses Windows to display data in a stripchart fashion, plus digital meter, analog meter, and bar graph formats. Expandable to 128 channels, the unit records temperature and voltage measurements that require channel-to-channel isolation. It provides 500V isolation for voltage inputs and 200V isolation for thermocouples.

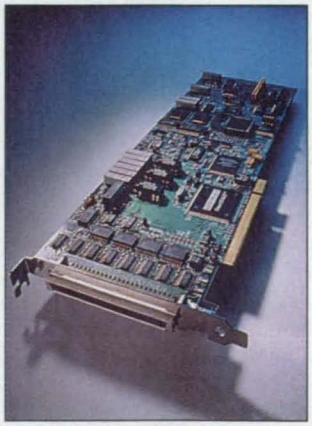
The recorder connects via modem or RS-232, IEEE 488, or RS-422/485 interface to a notebook or desktop PC. It also can operate as a standalone instrument. Other features include 32 built-in TTL alarm outputs, a 16-channel high-current drive option, and a choice of five interchangeable 16-channel scanning modules offered with four different connection types: BNC connectors, safety jacks, removable screw terminal blocks, or t/c mini-plug input connectors.

For More Information Circle No. 740

The AstroDAQ 2 portable **data acquisition system** from Astro-Med, West Warwick, RI, is packaged in a portable case the size of a notebook computer. Windows-based AstroLINK software provides control and analysis, or real-time waveform monitoring and data review on a PC. It can record up to 20 channels with a maximum 5 kHz sample rate per channel. Up to 1000 records and 400 million samples can be stored on an internal 1 GB hard drive.

The system accommodates signal conditioners for recording voltage, current, strain, temperature, pressure, and motion. It also monitors data remotely while the user observes real-time data via modem on a PC. Up to ten units can be networked and controlled by a single PC via a high-speed ethernet network interface.

For More Information Circle No. 744



Keithley Instruments, Cleveland, OH, offers the SmartDAQ™ KPCI-5000 family of analog PCI-bus **data acquisition boards** that can be programmed for a high or low gain. The boards are designed to run independent of the PC. They contain the Motorola 56301 digital signal processor to perform memory, data management, and other tasks typically performed by a PC.

Features include 16 single-ended/eight differential analog-to-digital channels, 64 single-ended/32 differential analog-to digital channels, two 12-bit digital-to-analog channels with waveform-quality output, three counter/timers, 16 digital I/O lines, and eight priority-interrupt driven digital inputs. A range of software support is available for Windows 95 and NT applications.

For More Information Circle No. 745

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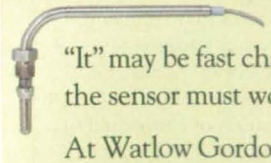

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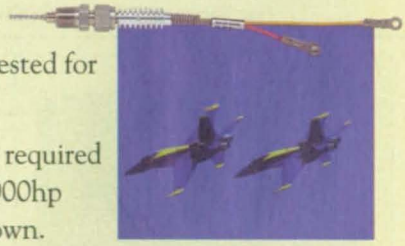

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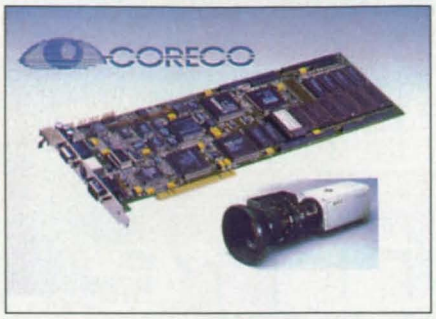


The TCI-SE, Digital-SE, and RGB-SE series of **PCI-based frame grabbers** for 24-bit acquisition of live video, digital camera output, and RGB acquisition, are available from Coreco, St. Laurent, Quebec, Canada. The boards enable real-time digitization and transfer of video data directly to memory. The TCI-SE is a single-slot system for image capture, transfer, and display.

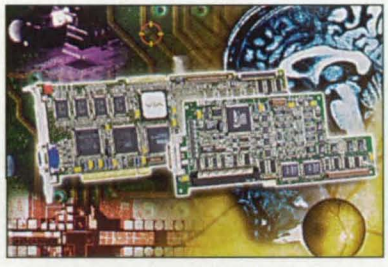
The Digital-SE is a computer interface to digital output cameras that transfers digital image data to the host or VGA at 66Mbytes/sec. A 16-bit differential digital input supports 8-, 10-, 12-, or 16-bit acquisition. The RGB-SE digitizes video from RGB cameras into 24 bits of true color and features input lookup tables for real-time video preprocessing.

For More Information Circle No. 736

ACCES I/O Products, San Diego, CA, has introduced the Model RAD128 eight-channel analog-to-digital **data converter/controller** that provides an optically isolated serial interface to any host computer with an RS-485 port. Applications include remote data acquisition, process monitoring and control, and building automation. The system's eight digital I/O lines may be programmed as an input or output.

Features include eight SE input ranges: ±10V, ±5V, 0-10V, and 0-5V; eight bits of digital I/O; an on-board crystal clock and three counter/timers for A/D conversion; and ASCII-based software. The system is housed in a rugged, stackable NEMA4 enclosure for use in commercial, marine, and other remote industrial environments.

For More Information Circle No. 739



The Genesis-LC PCI **frame grabber** from Matrox Imaging Products Group, Dorval, Quebec, Canada, is an analog/digital capture board with integrated display interfaces to most color or monochrome video devices. It simultaneously captures image data to display and transfer it to PC memory in real time. The board offers analog acquisition up to 140 MHz, up to 32-bit digital at up to 30 MHz, and frame or line scan input at up to 64K pixels per line and 64K lines. As many as four channels can be acquired simultaneously.

The board is programmable to accept signals from various devices such as scanning electron microscopes, high-resolution cameras, and medical scanners. It transfers data to memory at over 100 MB per second for simultaneous visualization and processing of data. A custom ASIC handles data management tasks.

For More Information Circle No. 746

LPTek Corp., Westbury, NY, has introduced LPTek **data acquisition boards** for test, measurement, control, and data acquisition through a parallel port. The boards include a parallel port control board and various application boards. All boards can be embedded in the user's system, or come packaged in the TMC port. In embedded systems, the data bus permits configuration of add-on cards as a mezzanine bus, enabling up to 16 boards in any combination to be standard.

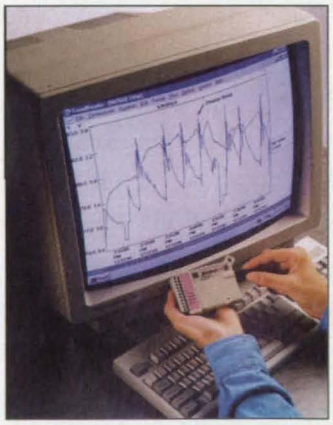
Incremental functionality can be added to data acquisition and control systems. Up to seven application boards can be purchased as a package. Applications include monitoring, signal conditioning, and on-board data acquisition for testing labs; creation of control simulations used in evaluation and testing; and field testing.

For More Information Circle No. 735

OMEGA Engineering, Stamford, CT, has announced the OM-2000 Series microprocessor-based portable, battery-operated **data loggers** that record and store data from one to six input channels, which are individually programmable for nine different thermocouple types and three dc voltage ranges.

Standard features include RS-232 communication interface, a 4-1/2-digit backlit LCD display, and analog output. A memory card option allows expansion of data storage capability.

For More Information Circle No. 737



The SmartReader Plus Model 2 **temperature and relative humidity data logger** from ACR Systems, Surrey, BC, Canada, has memory capacity to store 87,000 readings. The 12-bit logger has a temperature range from -40°F to 158°F and a humidity range from 0 to 100% non-condensing. Humidity measurements are N.I.S.T. traceable.

The unit features onboard temperature and relative humidity sensors and connections for external sensors, which can extend as far as 100 feet from the logger. It features standalone, ten-year, self-powered operation. Logged data is retrieved to any PC locally or over a phone line, and can be displayed graphically and statistically with the company's TrendReader software for Windows.

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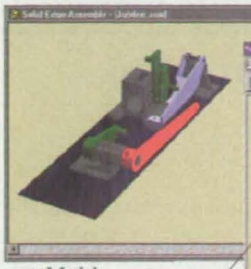

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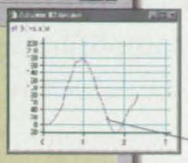

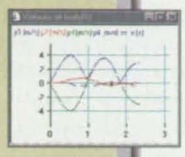

Subway Door Mechanism
Modeled by Sean Taffert
Vapor Canada Inc., Quebec, Canada

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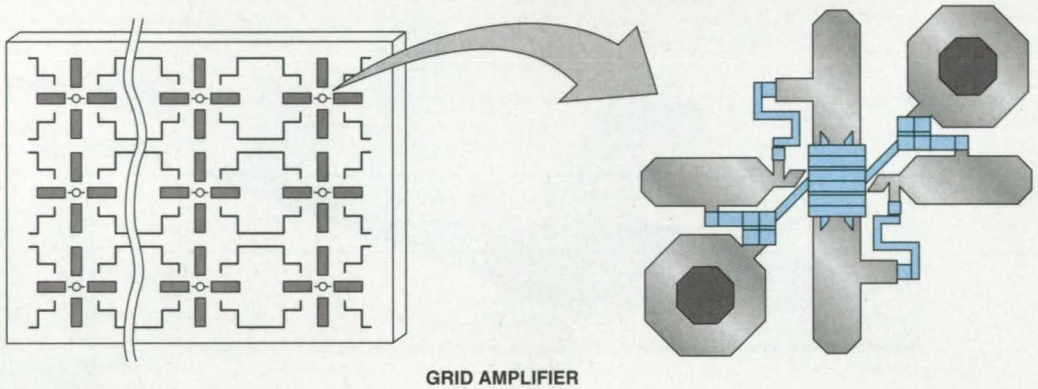
Generalized Scattering Matrices for Quasi-Optical Circuits

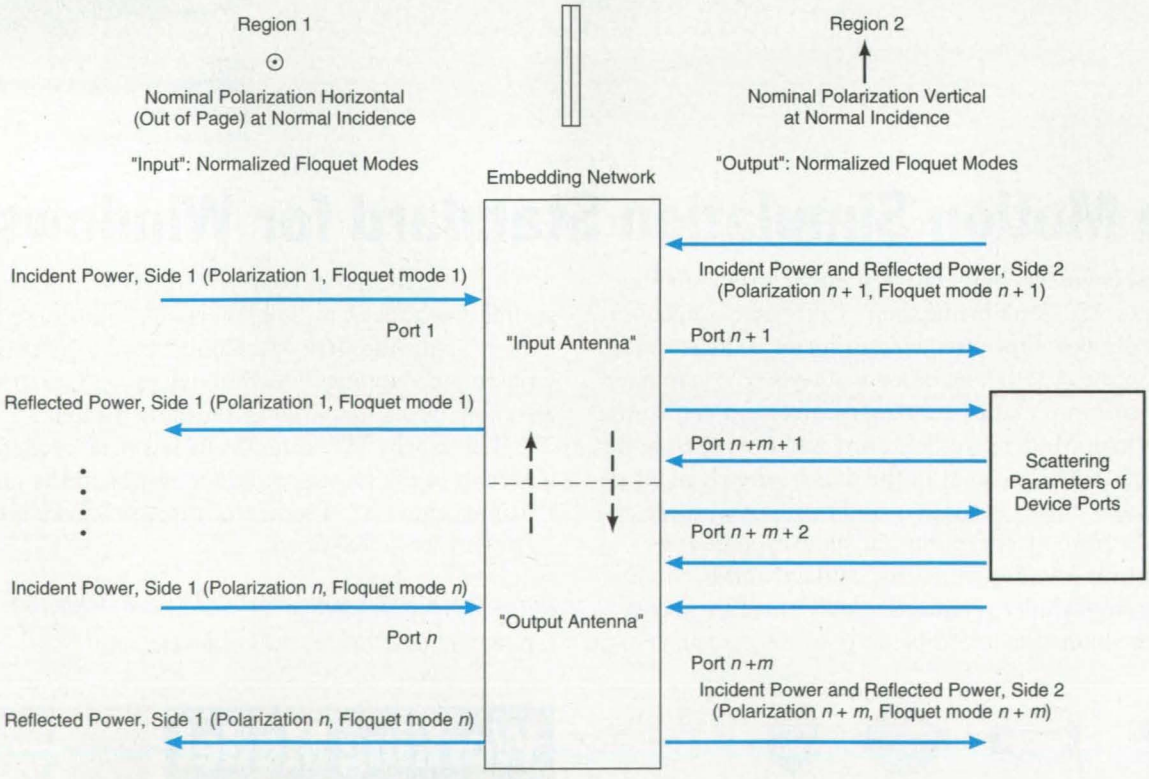
Analysis of grid amplifiers and oscillators is unified with preexisting theory.

NASA's Jet Propulsion Laboratory, Pasadena, California

A generalized-scattering-matrix approach provides a theoretical foundation for analysis and design of grid amplifiers and grid oscillators (periodic planar arrays of microwave amplifiers or oscillators with antennas, dc bias lines, and possibly other circuit elements). The generalized-scattering-matrix approach involves mathematical modeling that accounts for (1) the quasi-optical nature of electromagnetic fields that excite and are excited by the circuitry, (2) the periodicity of the circuitry, and (3) the parameters of solid-state devices in the circuits. This

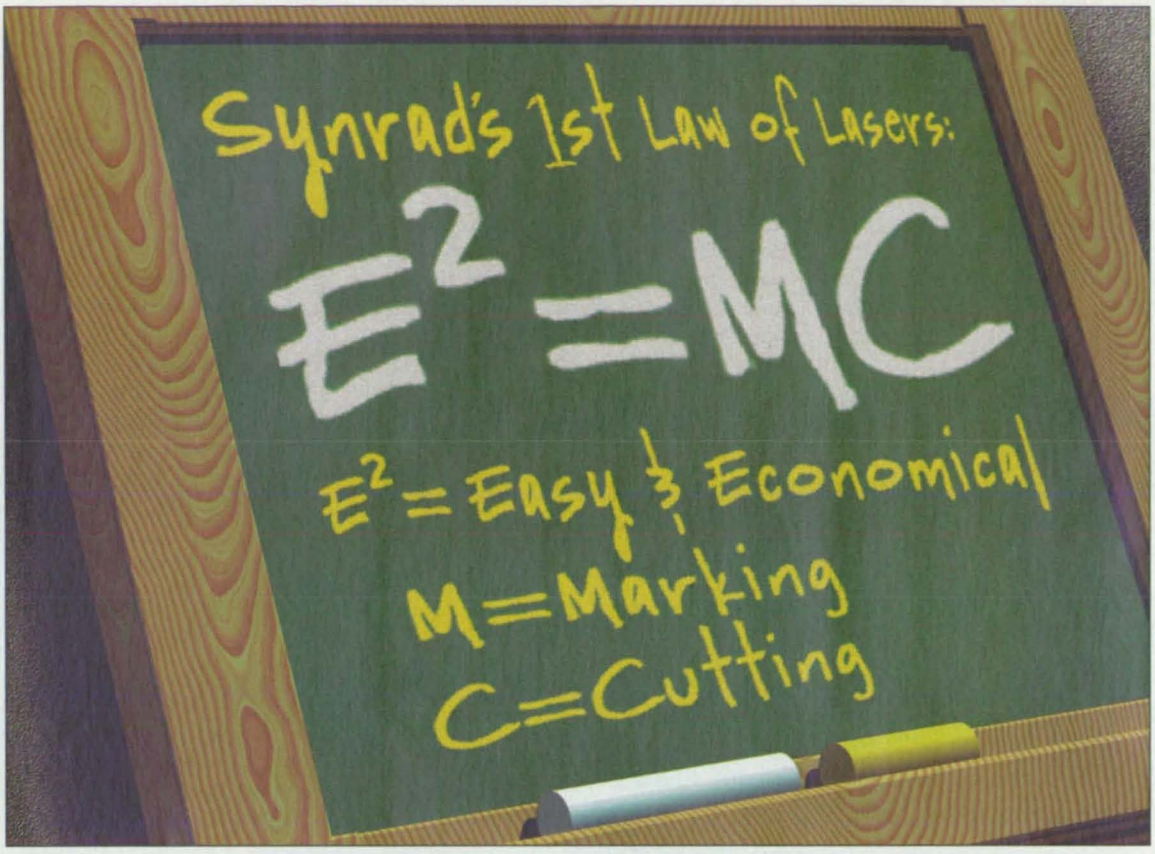


GRID AMPLIFIER



SCATTERING-MATRIX AND FLOQUET-HARMONIC REPRESENTATION OF ELECTROMAGNETIC FIELDS

A **Typical Grid Amplifier** contains a differential pair of high-electron-mobility transistors (HEMTs), with input and output antennas nominally decoupled by orthogonality of their polarizations at normal incidence. The components of the electromagnetic field on both sides of the amplifier plane are represented by Floquet harmonics in the half spaces designated as regions 1 and 2.



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approach unifies the analysis and design of grid amplifiers and oscillators with preexisting amplifier theory, making it possible to design improved quasi-optical circuits for monolithic fabrication on single wafers. The generalized-scattering-matrix approach also provides means to deembed the parameters of an active device from transmission and reflection coefficients measured in a test of a single unit cell in a waveguide simulator; this deembedding concept was described in "Scattering-Matrix Deembedding From Waveguide Simulator Test" (NPO-19554) *NASA Tech Briefs*, Vol. 21, No. 2 (February 1997), page 32.

For purposes of this approach, the parameters of a semiconductor electronic device in a grid amplifier or oscillator are presented in the scattering-matrix ("S-parameter") format that is also used to represent the transmission and reflection properties of waveguides. (Each coefficient or S-parameter is a transmission or reflection coefficient indexed to an input and/or an output port.) The periodic nature of the grid amplifier or oscillator is incorporated into the mathematical model of the circuitry by use of a generalized scattering matrix, wherein the electromagnetic scattering characteristics of the array are modeled by use of Floquet harmonics, as though each such harmonic represented a port of the amplifier or oscillator array. These "ports" are combined with power-wave representations of the device ports in the grid plane. Magnetic and electric wall assumptions are not needed in this method. Furthermore, in the Floquet-mode representation, scattering matrices can be cascaded to model the effects of nonnormal incidence, of coupling between input and output antennas, and of substrates, superstrates, polarizers, dc bias lines, and other periodic structures.

The top part of the figure illustrates a typical grid amplifier. In each unit cell, the location of attachment between the horizontal dipole antenna and the gates of the transistors constitutes the input port, while the location of attachment between the vertical dipole and the drains of the HEMTs constitutes the output port. One seeks the generalized scattering matrix, S^{num}, that describes the periodic array. So that a single unit can be modeled readily, the array is assumed to be infinite. A unit cell is described in terms of the currents on its metallic surfaces. The scattered fields generated by these currents are expressed as Floquet harmonics, and each such harmonic is regarded as a port. To find S^{num}, the array is excited with an incident Floquet harmonic at one port, and the coefficients of the scattered harmonics in region 1 and region 2 are computed with all ports matched.

Since the infinite half spaces are inherently matched, it is necessary to match the device ports (the input and output ports mentioned above). First, for each port, one computes an input impedance, which is then used as the reference impedance for the location of the port. The scattering parameters between the incident Floquet harmonic ports and all the other ports, including device ports, are then found directly. The scattering parameters between device ports and Floquet harmonics are then computed from the symmetry of the generalized scattering parameters.

This work was done by Larry W. Epp of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category,* ***or circle no. 114*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

NPO-19775

Optical Monitoring of Deflections of Compressor Blades

Fiber-optic sensors indicate deflections and blade-tip clearances in real time.

Lewis Research Center, Cleveland, Ohio

A compact instrumentation system has been developed for use in remote monitoring of the vibrational modes and static deflections of compressor blades, especially in aircraft engines. The system includes state-of-the-art integrated fiber-optic sensors and a state-of-the-art electronic processing subsystem with parallel-processing capability. Together, the optical and electronic subsystems provide simultaneous, near-real-time measurements of the deflections and tip clearances of compressor blades with timing resolution of 5 nanoseconds.

Each fiber-optic sensor tip contains transmitting and receiving optics needed to measure blade arrival. These optics include a gradient-index fiber lens fused to a monomode optical fiber for delivering, to a passing blade tip, a spot of coherent light about 50 μm wide. An array of high-numerical-aperture fibers gathers diffusively scattered light and transmits it to avalanche photodiodes, the outputs of which are processed in the electronic subsystem to extract the required information. Several fiber-optic sensor tips positioned along the blade chord provide measurements containing information on vibrational modes.

This work was done by Anatole P. Kurkov of **Lewis Research Center** *and Harbans S. Dhadwal, Romel Khan, and Ali Mehmud of the State University of New York at Stony Brook. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category,* ***or circle no. 124*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-16068.

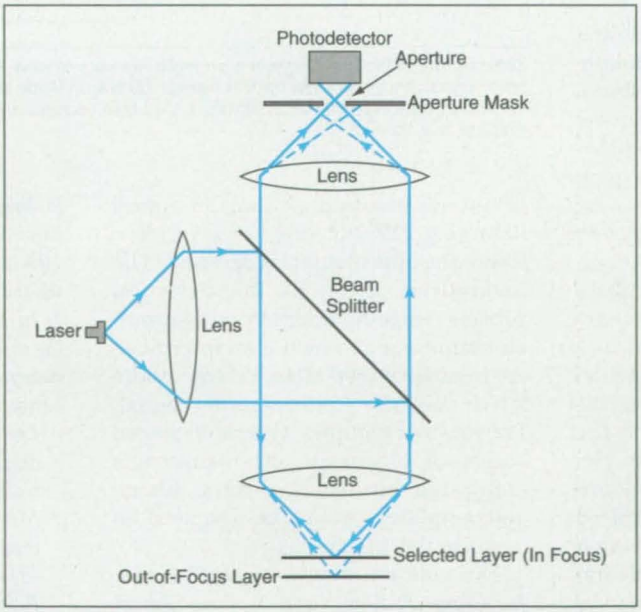
Improved Multilayer Optical Memory System

Improvements would be made in readout optics, identification of layers, and compositions of layers.

Lyndon B. Johnson Space Center, Houston, Texas

A proposed optoelectronic memory system based on a multilayer read-only optical disk would incorporate three improvements over a previous system of this type. As in the previous system, binary data would be stored in the spatially varying reflectivities of spiral tracks in multiple layers in the disk, light from a laser would be focused onto a selected layer, and the data stored in that layer would be read out via the reflected light. The proposed system would differ from the previous system in the readout optics, the method of identification of layers, and the compositions of the layers.

The figure is a greatly simplified schematic diagram of the readout optics. The improvement in the readout optics would consist of the addition of an aperture at the spot onto which light reflected from the illuminated spot in the selected data-storage layer would be focused. The aperture would be large enough to allow a substantial portion of the desired focused light reflected from the selected layer to pass through to the photodetector. The aperture would also be wide enough to provide sufficient range for a focus-control subsystem. At the same time, the aperture would be small enough so that the aperture mask would block most of the out-of-focus light reflected from the other layers, so that the aperture would help to prevent readout crosstalk between layers.



The **Aperture Mask** would block most of the light reflected from layers out of focus; only the light reflected from the selected layer would be focused into the aperture and thereby allowed to pass unimpeded to the photodetector.

Previously, the data-storage layers in a disk were identified via codes incorporated into the stored data by use of additional bits. In the proposed system, there would be no need for these codes and the extra bits. Instead, upon insertion of a new disk in the proposed system, the optical readout head would be set at the top of its travel, then scanned downward until it encountered the uppermost layer in the disk. It would read the directory of that layer, then scan down to the next layer and scan its directory, and so on, down to the lowermost layer. The system would track its location by counting the passage of layers. Thereafter, upon a request by the user for information in a given layer, the optical readout

head would be scanned upward or downward from its present location, counting the passage of layers until it reached the given layer.

In this scheme, it would be desirable to have redundant information to verify the identity of the layer as determined by counting. This is because, for example, a mechanical shock during scanning could cause a layer to be skipped. In the proposed system, the redundant layer-identification information would lie in the average amplitude of the readout signal; the average reflectivity of each layer would have a unique value, so that the average level of the readout signal from each level would have a unique value. During the initial downward scan through a new disk, the system could record the average readout signal from each layer. During subsequent readout from that disk, the system could compare the average readout signal with the recorded value for the layer being read to verify the identity of the layer.

Previously, it had been proposed to store data in contrasting dielectric layers to avoid the absorption losses that are associated with the use of metallic films as reflective elements. However, research has since shown that it may be desirable to use metallic films to obtain high (≈50 percent) reflectivities. By making these films thin enough (≈10 nm thick), it should be possible to minimize absorption losses. In particular, gold appears to be the material of choice for enhancing the reflectivity of the second-deepest layer. The deepest layer could be made of aluminum and it could be made relatively thick because absorption is not a concern for that layer.

This work was done by James Strickler of Strickler Optical Technology, Inc., for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category,* ***or circle no. 105*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

MSC-22452/53/54

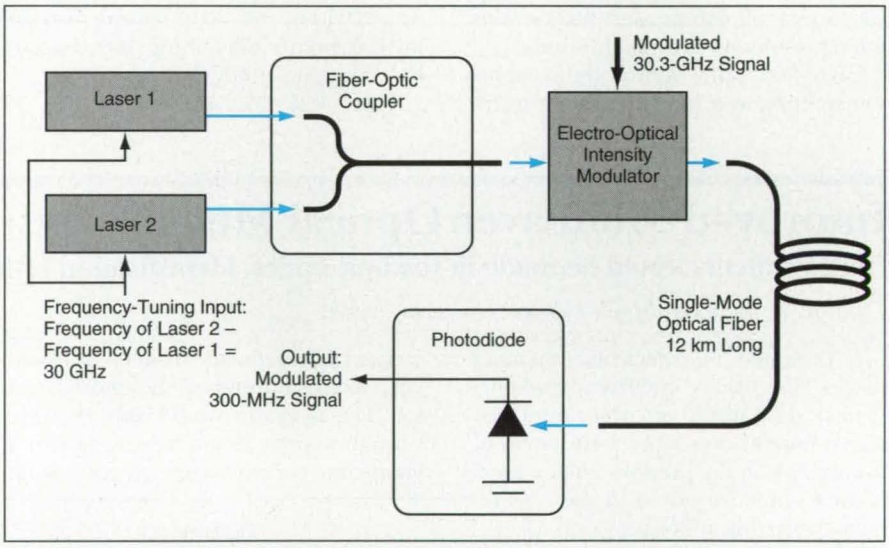
Photonic Processing of Multigigahertz Signals

Optoelectronic heterodyning is among the techniques used.

NASA's Jet Propulsion Laboratory, Pasadena, California

Some disparate elements of fiber-optic, electro-optical, and optoelectronic technology have begun to coalesce in the development of a unified partly photonic, partly electronic approach to the processing (including generation, transmission, and reception) of electromagnetic signals at frequencies of about 1 to 300 GHz. Photonic technology now appears to be a viable alternative to traditional electronic-only technology for realizing the building blocks of advanced communication systems that will exploit the advantages (light weight, low loss, compactness, large bandwidth) of fiber-optic transmission media, compared to transmission of multigigahertz signals over metallic waveguides.

The figure schematically illustrates one example of an application following this approach. The two lasers shown at the left side of the figure are narrowband units that are tuned so the difference between output frequencies equals a desired microwave or millimeter-wave heterodyne beat frequency, e.g., 30 GHz. A stable electronic reference signal can be used to maintain phase coherence between the lasers. The outputs of these lasers are combined in a fiber-optic coupler, then amplitude-modulated by a modulated carrier signal that differs in frequency from the first-mentioned heterodyne beat frequency by a relatively small amount (e.g., 300 MHz) that equals the desired intermediate frequency to be generated at the receiving end. The modulation on the 30.3-GHz modulating carrier signal is the information signal to be downconverted and transmitted.



This Photonic/Electronic System is a simple example of how a system effects (1) up-conversion of electrical signals to modulated optical signals, (2) transmission along an optical fiber, and (3) down-conversion of optical to electrical signals. Other architectures are possible for up-conversion, phase modulation, and the like.

The combined, modulated laser beams are transmitted along an optical fiber (e.g., 12 km long) to a receiver, where the optical signal is detected. The heterodyne action of the detection process yields the desired downconverted output signal, which is an intermediate-frequency (300-MHz) carrier modulated by the information signal. Previously, a complex system of several stages of electronic downconverters employing electronic mixers, filters, and amplifiers would be required to perform this function.

This work was done by Ronald T. Logan, Jr., George F. Lutes, and X. Steve Yao of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category,* ***or circle no. 109*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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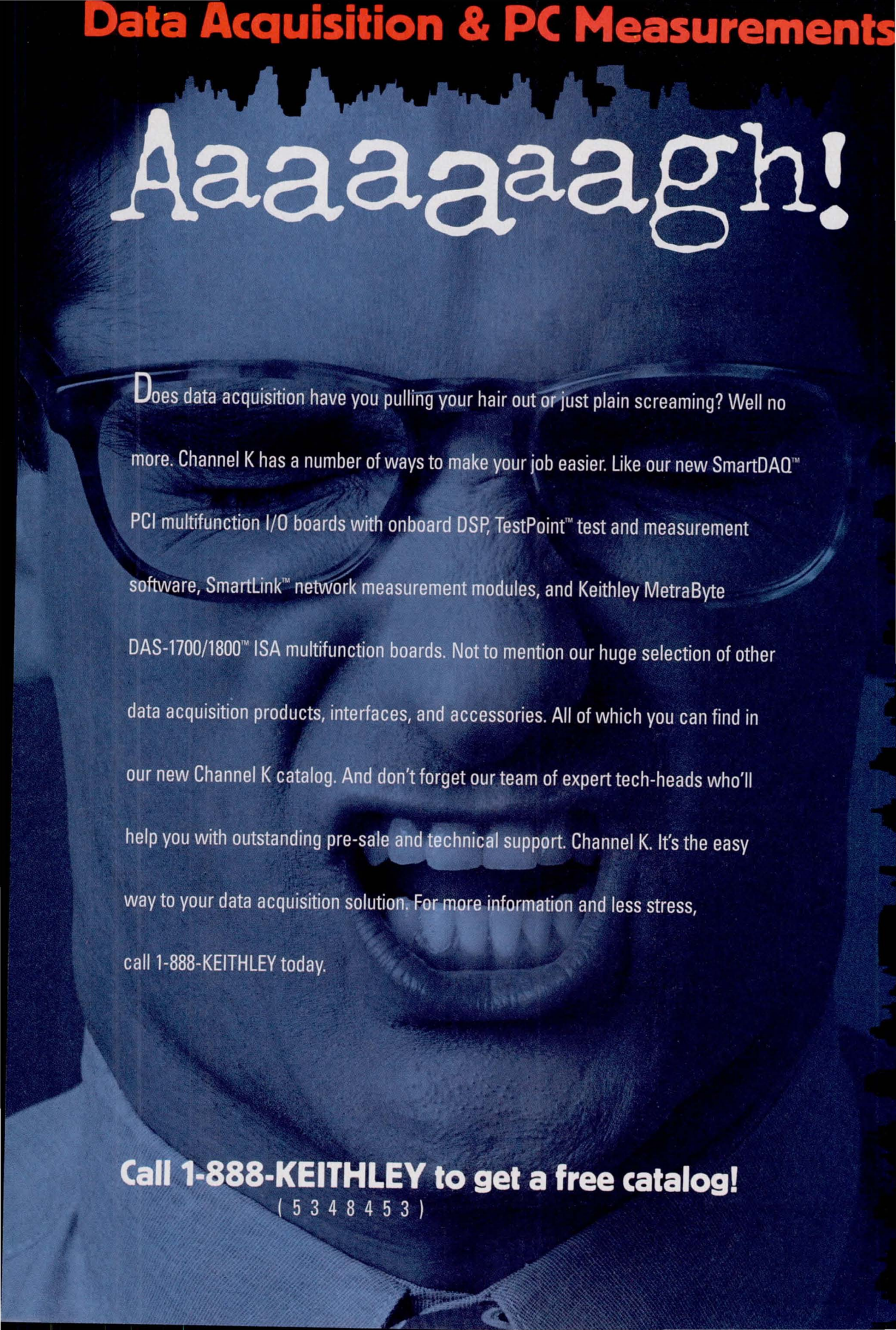
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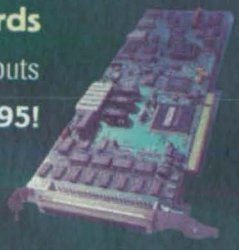

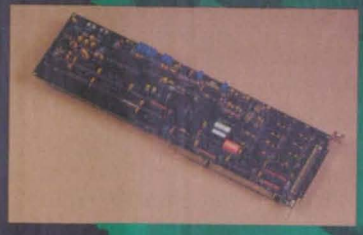

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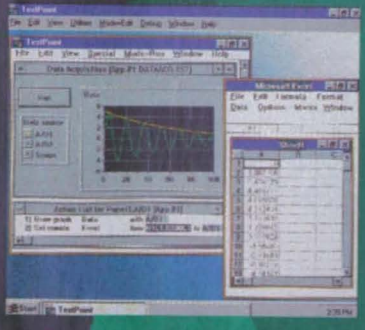

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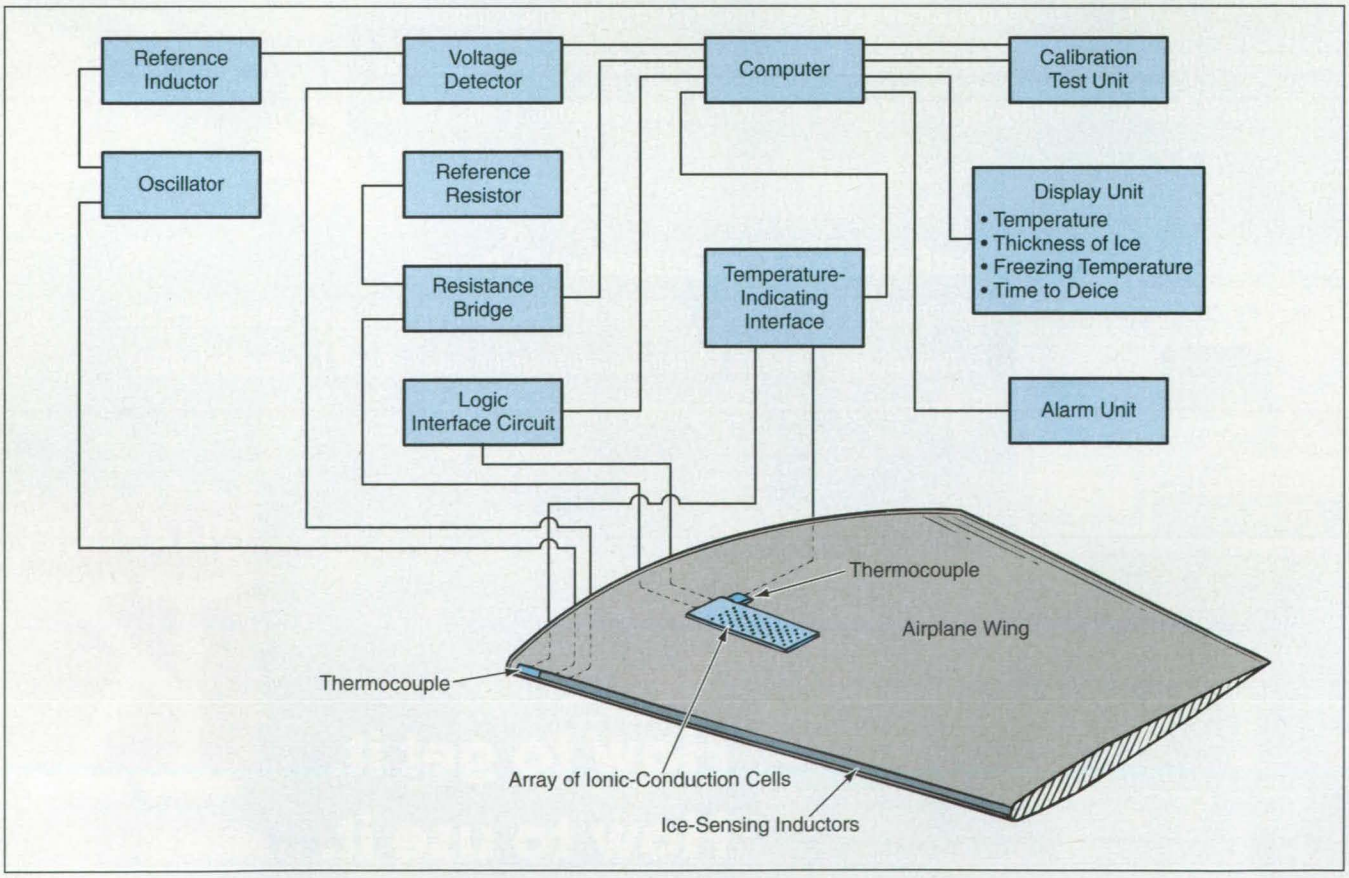
The crew is alerted to the need for corrective action.

Ames Research Center, Moffett Field, California

An instrumentation system measures the thickness of ice and provides information on the effectiveness of deicing fluid on critical surfaces of an aircraft. By providing an early indication of the accretion of ice during flight, the system enables the crew of the aircraft to make a timely correction (e.g., changing course and/or altitude) before the ice becomes dangerously thick. When the aircraft is on the ground, the system can be used to determine whether there is a need to spray deicing fluid on the wings and other critical surfaces; thus, the system provides guidance to ensure that the amount of deicing fluid used is sufficient to ensure safety but is no more than that, thereby helping to minimize pollution of the airport environment from excess deicing fluid.

The system (see figure) includes ice-sensing inductors and a thermocouple embedded in a thin layer of dielectric material on a critical aircraft surface, a thin array of ionic-conduction cells and another thermocouple mounted on another critical aircraft surface (or on a different part of the same surface), and an assembly of analog and digital electronic circuits. The ice-sensing inductors comprise a transmitting and a receiving inductor; in effect, primary and secondary transformer windings. The transmitting inductor is excited by an oscillator at an audio or radio frequency chosen so as not to interfere with other electronic equipment in the aircraft. The coefficient of coupling between the two inductors, and thus the output voltage of the receiving inductor, depends on the thickness of overlying ice. Accordingly, the output of the receiving inductor is processed via a voltage detector and a computer, wherein it is compared with a reference voltage to determine the thickness of ice. The reference voltage for this purpose is determined during operation in a calibration mode, in which the excitation is supplied to a reference inductor instead of the ice-sensing inductors. The temperature reading provided by the thermocouple mounted with the ice-sensing inductors constitutes additional information that the computer uses to determine whether the measurement indicates the thickness of ice or indicates something else.

The array of ionic-conduction cells provides measurements of the surface



This **Instrumentation System** determines the ambient temperature, the thickness of ice (if any) in one area, and the freezing temperature of liquid (if any) in another area. The system also extrapolates the trend in the condition of the liquid to predict the time remaining until the liquid freezes.

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electrical conductivity, which is an indication of the ionic conductivity and thus the concentration of deicing fluid in the surface film of liquid that remains after deicing fluid has been sprayed on and the excess has dripped off. By use of a logic interface circuit operating under computer control, the cells in the array can be activated one at a time and interrogated via a resistance bridge to obtain spatially resolved data on the concentration of deicing fluid. During operation in the calibration mode, the resistance bridge is connected to a reference resistor instead of one of the ionic-conduction cells.

The concentration of deicing fluid in the surface film of liquid decreases as the film becomes diluted with liquid water from fog, rain, snow, and/or melting ice. The freezing temperature of the film increases with decreasing concentration in a known way; thus, the computer is programmed to calculate the present freezing temperature of the surface film of liquid from the concentration as determined from the conductivity measurements. The computer compares this freezing temperature with the actual ambient temperature measured by the thermocouple mounted with the ionic-conductivity cells. It also extrapolates the trend of recent conductivity measurements to predict when the freezing temperature will reach the actual ambient temperature. The predicted time thus serves as a deadline to spray on more deicing fluid or take other corrective action.

This work was done by H. Lee Seegmiller of **Ames Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 112*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

This invention has been patented by NASA (U.S. Patent No. 5,523,959). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-12045.

Laser Vibrometry of Supported Membranes

Stresses can be computed from modal responses.

NASA's Jet Propulsion Laboratory, Pasadena, California

A laser-vibrometric apparatus yields measurement data from which one can compute stresses in thin, small-area membranes supported rigidly around their edges. The apparatus was designed especially for testing amorphous (in the sense of noncrystalline) metallized composite membranes like those used in x-ray lithography masks, millimeter-wave transmission lines, and microelectromechanical devices. Stress-measuring techniques based on x-ray diffraction or Raman spectroscopy are not effective when applied to amorphous membranes, but laser vibrometry can be used without regard to the presence or absence of crystalline microstructure. In addition, laser vibrometry can be used to characterize dynamic (modal) responses, and is applicable to irregularly shaped membranes.

In the apparatus (see figure), a frame or substrate that supports a specimen membrane is mounted on a specimen holder in front of a loudspeaker, which is driven at controlled amplitude and frequency to excite vibrations in the membrane. A laser vibrometer measures the vibrational response (amplitude and phase of displacement as a function of

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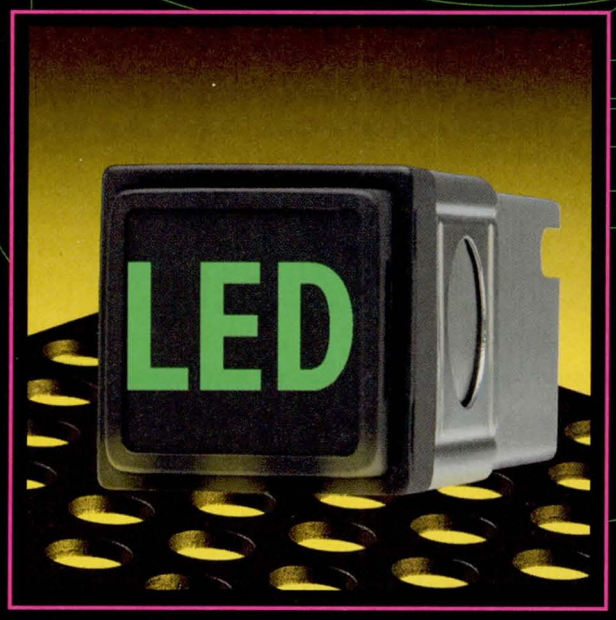

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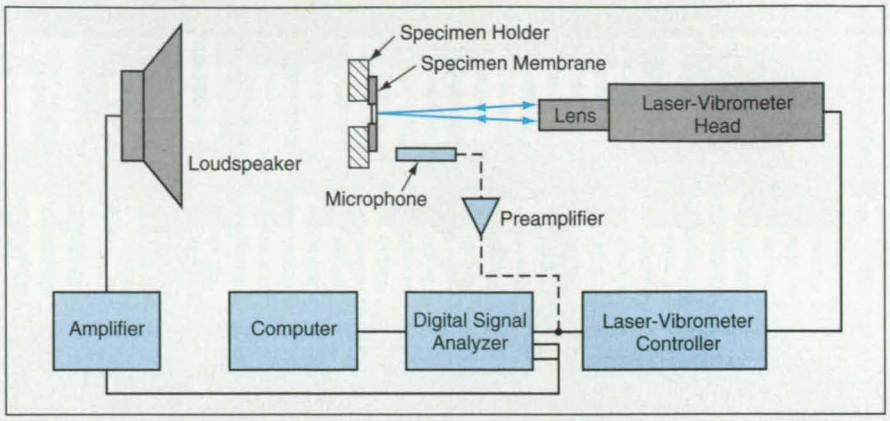
frequency) at selected locations on the membrane. A digital signal analyzer preprocesses the output of the laser vibrometer to furnish frequency, displacement, and phase information to a computer for further analysis. To obtain calibration data for use in accounting for the frequency response of the loudspeaker, the specimen can be removed and replaced by a microphone to measure the acoustic pressure as a function of frequency.

Typically the analysis is directed toward identification of vibrational modes and their resonance frequencies. The resulting data can then be used to compute stresses. For example, in the case of a homogeneous rectangular membrane of dimensions L_x by L_y and mass density ρ subject to uniform biaxial tensile stress σ, one can compute the stress from

$$\sigma = \frac{2\rho f_{mn}^2}{\left[\left(m/L_x\right)^2 + \left(n/L_y\right)^2\right]}$$

where m and n are integers that denote a vibrational mode and f_{mn} is the resonance frequency of that mode. In the case of an inhomogeneous and/or irregularly shaped membrane, the interpretation of measurement data is more complex, involving finite-element analysis to match predicted vibrational responses to the measured responses at all frequencies and locations of interest.



The **Laser Vibrometer** interferometrically measures the displacement at one spot on the vibrating membrane. Measurements are taken at various spots and frequencies to obtain data on vibrational modes.

This work was done by Abhijit Biswas of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 113*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*
NPO-19751

Laser Extensometer for Noncontact Measurement of Strain

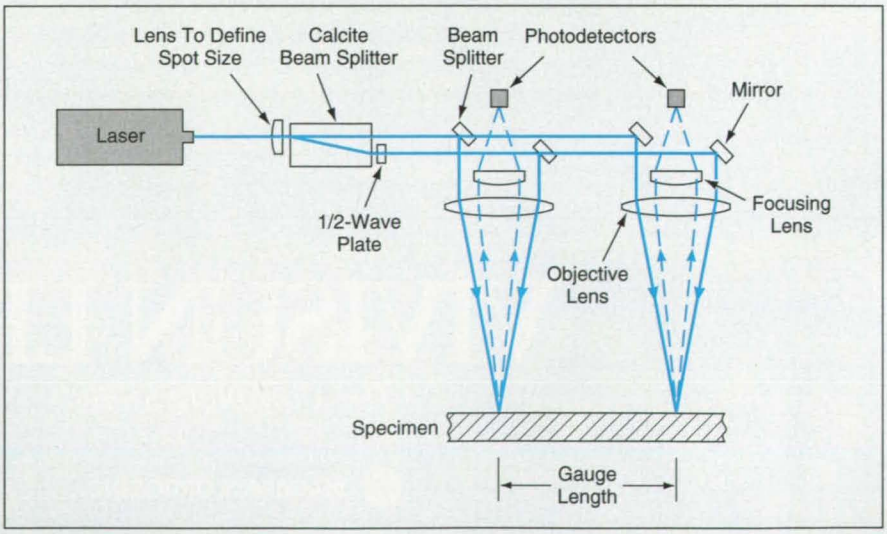
Strains in hot specimens can readily be measured in real time.

Lewis Research Center, Cleveland, Ohio

A laser extensometer provides noncontact measurements of strains, which could be steady or varying with time. This instrument is relatively easy to use and is especially well suited for measuring strains during tensile and fatigue tests of material specimens at temperatures up to 2,000 °F (1,100 °C). It is not necessary to prepare the surface of a specimen, nor is it necessary to place any part of the instrument in a hot test environment. Instead, this instrument is mounted on a tripod, facing the specimen (if necessary, through a test-chamber window) from a standoff distance of 8 in. (20 cm).

The laser extensometer is based on an interferometric principle that involves spatial and temporal heterodyning via a unique combination of techniques related to those of laser velocimetry and speckle metrology. The laser extensometer (see figure) includes a stabilized, two-frequency (Zeeman-split), helium/neon laser that produces two beams with orthogonal polarizations and with frequencies that differ by precisely 250 kHz. A calcite beam splitter separates the two beams laterally, then a half-wave plate rotates the polarization of one beam to make it parallel to the polarization of the other beam so that the two beams can subsequently be made to interfere with each other.

An assembly of beam splitters and lenses directs the beams onto the specimen surface at two spots. The distance [1 in. (2.54 cm)] between the spots constitutes the gauge length for measuring strain. At each spot, the beams are incident from opposing angles ($+\phi$ and $-\phi$) relative to the perpendicular to the surface, and thus form interference fringes on the surface. The distance *(d)* along the surface between successive fringes is given by $d = \lambda/2\sin\phi$, where λ is the wavelength of the laser beams. Light from the interference fringes in each



The **Optical Components of the Laser Extensometer** are arranged to provide for noncontact, interferometric measurement of strain in the specimen. The instrument is sensitive to strain along the line between the illuminated spots, and is insensitive to rigid-body motion of the specimen.

spot is reflected to a photodetector in the optical head that contains the beam splitters and lenses; the inherent partial diffuse reflectivity of almost any specimen surface results in scattering of sufficient light for measurement by the photodetectors.

The temporal variation of difference between the phases of the two beams causes the interference fringes to move along the surface so that at each spot, the brightness fluctuates and the fluctuations can be measured in the output of the corresponding photodetector. When the surface remains fixed relative to each spot, the output of each photodetector includes a sinusoidal component that varies with time at the beat frequency of 250 kHz, and the difference between the phases of these components of the outputs of the two photodetectors remains constant.

When the reflective particles on the surface move against or with the motion of the fringes with a speed v, the frequency increases or decreases, respectively, by an amount v/d, and the difference between the phases varies accordingly. The phase of each photodetector output is compared with a reference phase, obtained from a detector inside the laser, that is used to stabilize the laser difference frequency at 250 kHz. A digital phase meter tracks the resulting relative phases and the difference between them; this phase difference is a direct measure of the strain along the line between the illuminated spots on the specimen. Because of the differential nature of the difference between the relative phases, the effect of any rigid-body motion of the specimen is automatically canceled.

This capability of the laser extensometer has been demonstrated in measurements on a variety of surfaces at temperatures up to 1,000 °C. Measurements are updated at a sampling rate of 125 kHz, and the update rate for display of output data is 2.5 kHz. The instrument can resolve strains as small as 5×10^{-6}.

This work was done by David L. Carlson of Optra, Inc., and David W. Voorhes of Lytron, Inc., for **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 155*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

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Covalent Cross-Linking for Strengthening Composite Materials

Fiber molecules would be covalently bonded to matrix molecules.

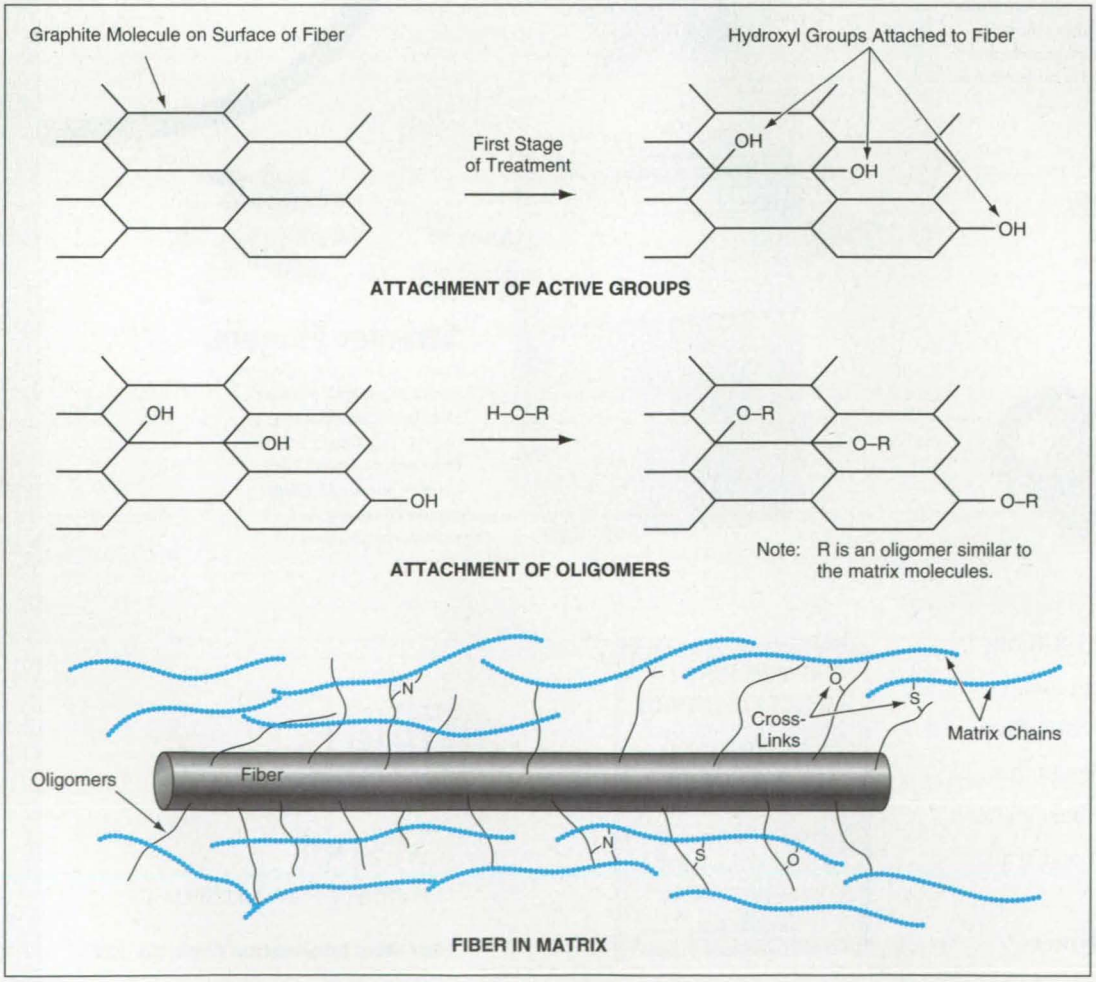
Lewis Research Center, Cleveland, Ohio

In a proposed method of strengthening matrix/fiber composite materials, surfaces of fibers would be chemically treated to provide some covalent bonds between fiber and matrix molecules. The method was conceived in an effort to strengthen bonds between carbon fibers and rubber matrices in tires, but should also be applicable to fibers made of other materials and to various polymeric matrix materials.

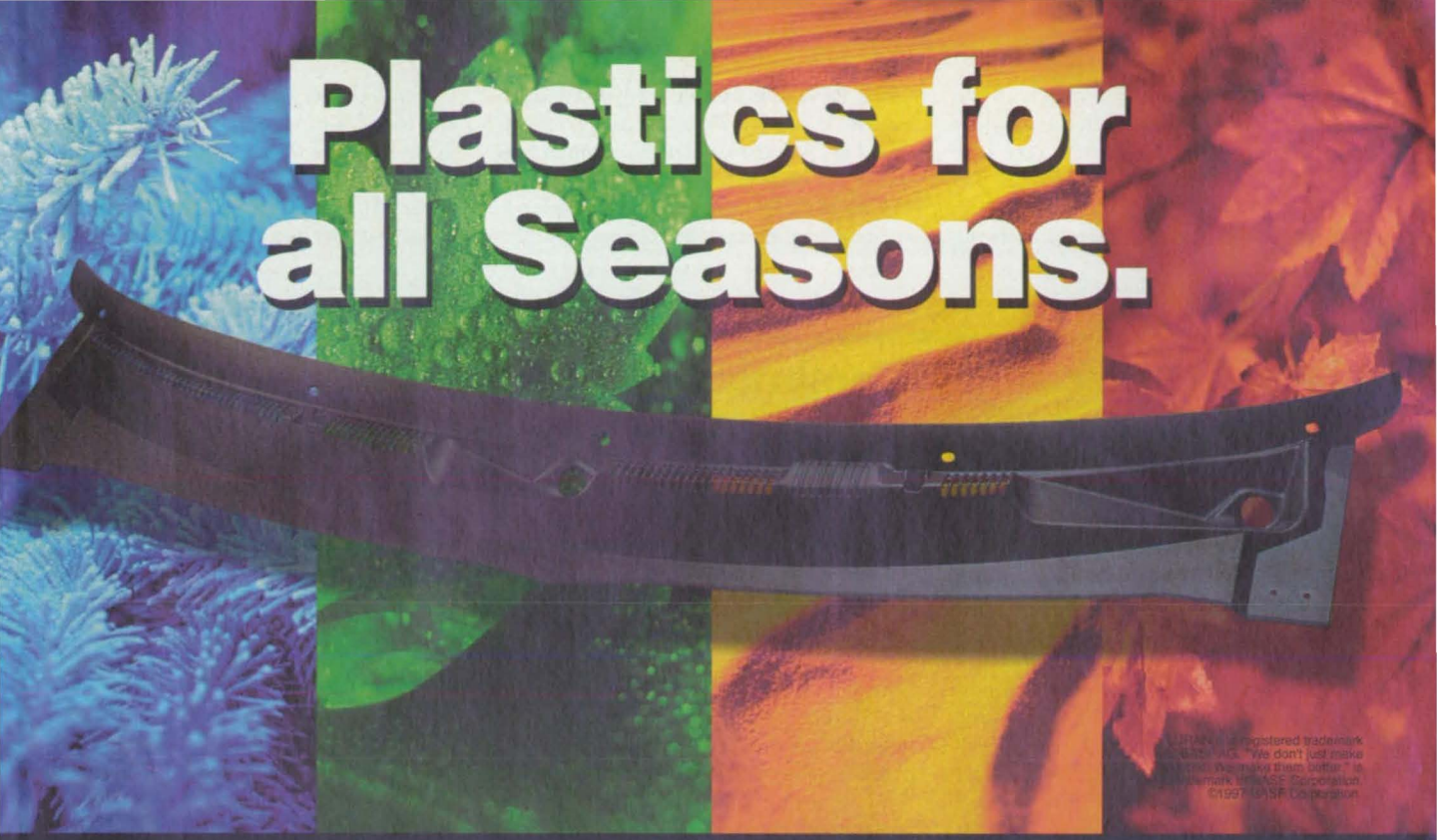
The figure illustrates the basic principles of the method as applied to carbon (in particular, graphite) fibers in a polymeric matrix. In preparation for chemically treating the fibers and incorporating them into the matrix, one would choose a chemically active group capable of attachment to at least two sites — one on the graphite surface of the fiber and one on an oligomer to be added subsequently. Examples of groups that would be suitable for this purpose include hydroxyl (–OH), amino ($–NH_2$), cyano (–CN), and thiol (–SH). The chosen groups would be attached to the fiber in the first stage of treatment. For example, hydroxyl groups could be attached by one or more of several oxidation treatments that could include the use of nitric, sulfuric, or perchloric acid; superheated steam; heating in air; plasma ashing; and/or beams of oxygen ions. The number of groups attached could be controlled, by adjusting treatment conditions, to optimize the fiber/matrix bond to be formed subsequently.

In the second stage of treatment, oligomers similar to the matrix molecules (e.g., isoprenoids in the case of a rubber matrix) would be attached to the outer ends of the groups that had been attached to the fibers in the first stage of treatment. This could be done by addition of oligomers that form ester or ether linkages in the case of hydroxyl groups (or that form analogous linkages with whichever of the other groups is chosen). The resulting bonds between the oligomers and the fibers must be strong enough to withstand subsequent processing steps. The oligomers could be chosen to have lengths that are optimum for the desired matrix/fiber bonds. In effect, the fibers as treated thus far would have been made "hairy" by the attachment of oligomeric units.

In the third stage of treatment, the matrix precursor material would be introduced, and the resulting composite would be cured. As cross-links formed between matrix molecules during the curing process, some cross-links would also form between matrix molecules and the matrixlike oligomers attached to the fibers. Thus the oligomers and fibers would become covalently bonded to the matrix. Even if the matrix material were one that does not



Fibers Would Be Made "Hairy" by chemical attachment of oligomers. The oligomers would form covalent bonds and/or would tangle with matrix molecules, with resultant strengthening of matrix/fiber bonds.



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form covalent cross-links, matrix/fiber bonds could still be strengthened by use of long oligomers that would mix and tangle with molecular chains of the matrix.

This work was done by James R. Gaier of **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category,* ***or circle no. 159*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

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Polymeric Electrolyte Membrane Materials for Fuel Cells

Advantages include low cost, thermal stability, low methanol permeability, and high proton conductivity.

NASA's Jet Propulsion Laboratory, Pasadena, California

A class of improved proton-conductive sulfonic acid polymeric membranes has been developed for use as solid electrolytes in hydrogen/oxygen and direct methanol fuel cells. These membrane materials are denoted generally as highly sulfonated poly(ether ether ketone) (H-SPEEK). In comparison with previously developed commercial fuel-cell membrane materials, H-SPEEK is more stable in the optimum range of operating temperatures (100 to 200 °C), is less permeable by methanol, and costs less.

In an experiment on the preparation of H-SPEEK, 120 g of PEEK (grade 450p) was stirred in 1,200 mL of sulfuric acid at room temperature for 4.5 hours. The resulting homogeneous solution was heated to 91 °C for 1 hour. The reaction in the solution (see Figure 1) was then quenched and the solution cooled to room temperature. Once precipitated from the solution, the polymer was washed to remove excess acid. At an approximate pH of 5, samples of the polymer were dried under ambient conditions for various times from 36 to 72 hours. As thus prepared, H-SPEEK exhibited an equivalent molecular weight of 365 daltons. Unlike poly(ether ether ketone) (PEEK), H-SPEEK is soluble in aqueous organic solvents.

Once the H-SPEEK was dry, a 30-g sample was dissolved in an acetone/water solution. To this solution, approximately 3 g of glycerine was added, and the resulting mixture was filtered over a celite pack. From the filtered mixture, films were cast in low-thermal-expansion glass dishes, evaporation times ranging from 24 to 48 hours. The cast films had lateral dimensions of 6 by 8 in. (15 by 20 cm) and thicknesses ranging from 3 to 20 μm.

After the films were set, the dishes were heated to a temperature of 120 °C under vacuum to promote cross-linking (see Figure 2). The amount of cross-linking in each film was determined by the heating time. After the cross-linked films were removed from the dishes, they were conditioned in boiling water (to ensure the stability of the resulting membranes at high temperatures) and soaked to remove excess glycerine.

The equivalent molecular weight of one of the H-SPEEK films thus treated was found to be 504 daltons. Nuclear-magnetic-resonance analysis of this film prior to cross-linking indicated that there was one sulfonic acid group per molecular repeat unit. Back-titration of a series of solutions containing samples of this film taken after cross-linking indicated that 28 percent of its sulfonic acid groups had been converted to sulfone groups by the cross-linking process.

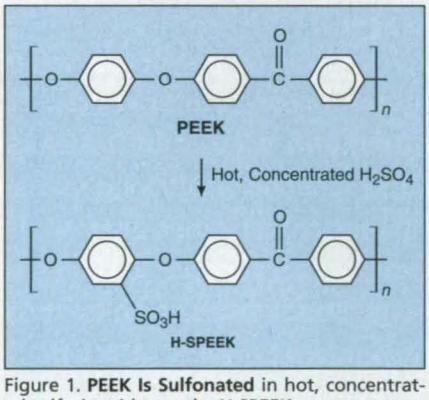

Figure 1. **PEEK Is Sulfonated** in hot, concentrated sulfuric acid to make H-SPEEK.

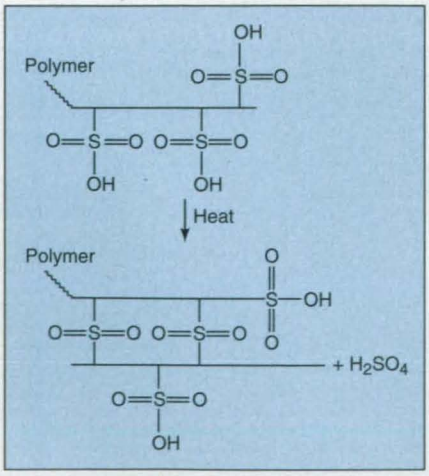

Figure 2. **H-SPEEK Can Be Cross-Linked** by heating, with conversion of sulfonic acid groups to sulfone groups. Cross-linking can impart desirable properties — notably, reduction of permeability by methanol.

H-SPEEK is soluble in such organic solvents and solvent mixtures as dimethyl formamide, dimethyl acetamide, n-methyl pyrrolidinone, dimethyl sulfoxide, and water/acetone. Prior to cross-linking, it is also soluble in water/methanol. Solutions of H-SPEEK in such solvents can be used to make proton-conductive binders in the fabrication of electrodes for fuel cells.

Membranes made from H-SPEEK have been found to be comparable to a commercial membrane with respect to mechanical strength and proton conductivity (the magnitude of which is determined by the degree of sulfonation). Cross-linking in H-SPEEK can be achieved without significant loss of proton conductivity. Accordingly, a combination of cross-linking within the membrane and modification of the surface of the membrane can be used to reduce the undesired permeability of an H-SPEEK membrane by methanol without greatly reducing the desired permeability of the membrane by protons.

This work was done by Shaio-Ping S. Yen, Eva Graham, Sekharipuram R. Narayanan, Andre Yavrouian, and Gerald Halpert of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category,* ***or circle no. 165*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

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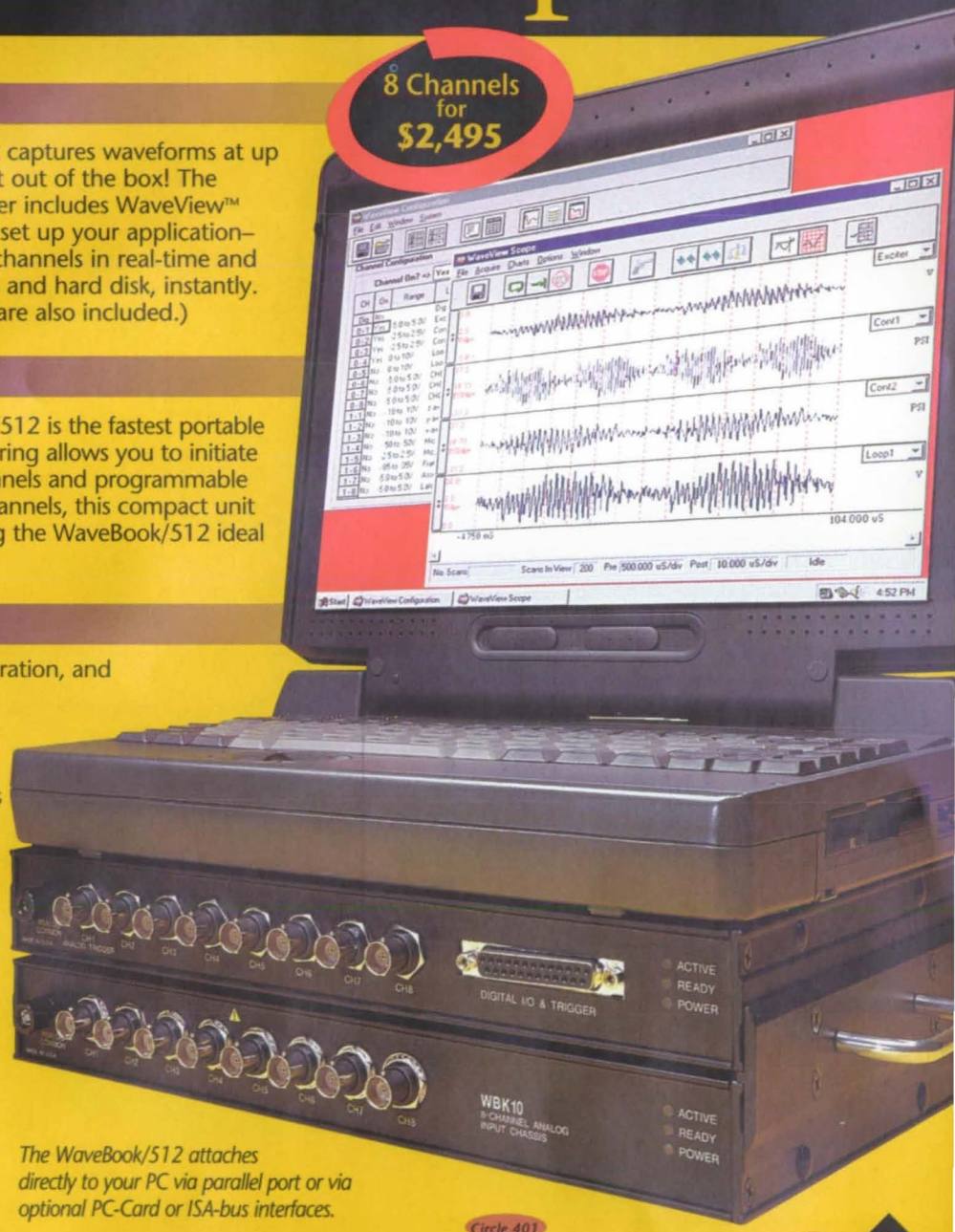

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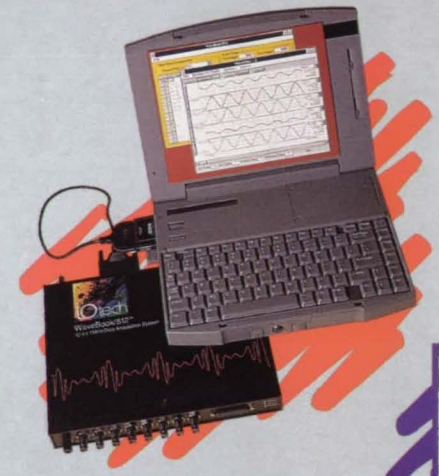

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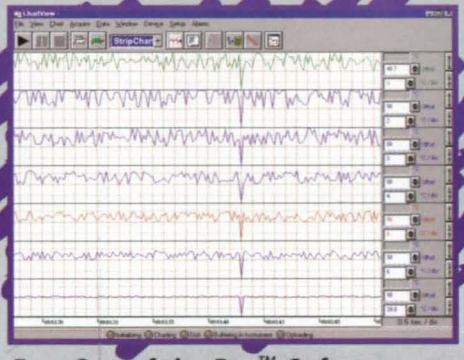

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This work was done by Steve Chien, Ray Lam, and Quoc Vu of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Computer Software category,* ***or circle no. 116*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-20084.

Software for On-Board Planning in a Nearly Autonomous System

The DS1 On-Board Planner and Scheduler (PS) software is a component of the artificial-intelligence system described in "A Remote Agent Prototype for Spacecraft Autonomy" (NPO-19992), *NASA Tech Briefs*, Vol. 21, No. 3 (March 1997), page 106. The artificial-intelligence system has been developed for use in small exploratory spacecraft and might also prove adaptable to other terrestrial robotic systems for which there is a need to implement nearly autonomous operation with only occasional high-level, possibly non-real-time human intervention. The PS software can reduce the cost and enhance the quality of a mission by (a) formulating detailed plans of action in response to high-level commands, (b) providing for robust responses to equipment failures to enable achievement of mission goals without human intervention, and (c) taking advantage of fortuitous events.

This program was written by Benjamin D. Smith, Steve A. Chien, David Yan, and Gregg Rabideau of Caltech; Nicola Muscettola of Recom Technologies; Chuck Fry, Kanna Rajan, and Sunil Mohan of Caelum Research; and Othar Hansson of Thinkbank, Inc., for. This program was written by Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Computer Software category,* ***or circle no. 117*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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Software Generates Commands for Operating Remote Instruments

The DATA-CHASER Automated Planner/Scheduler (DCAPS) computer program automatically generates sequences of low-level commands for remote control of equipment to achieve high-level goals defined by users. DCAPS is designed specifically for controlling the DATA-CHASER, which is a package of spectral imaging instruments to be flown aboard the space shuttle to observe the Sun. DCAPS utilizes artificial-intelligence techniques and a scheduling algorithm of the iterative repair type (algorithms of this type have been used in commercial operations). Like other iterative repair algorithms, this one iteratively and selectively resolves conflicts within the applicable constraints on time and resources. The DCAPS version of this algorithm is adapted specifically to the DCAPS commanding application. DCAPS provides for a natural representation of problems that arise in this application and for interaction with users, enabling them to become directly involved in the sequencing of commands. DCAPS provides for simple (from the users' perspective), nondisruptive rescheduling following any changes in the state of the spacecraft or in goals defined by the users.

This program was written by Steve Chien, Gregg Rabideau, Tobias Mann, and Peter Stone of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Computer Software category,* ***or circle no. 118*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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Prototype System for Development of Scheduling Software

The Automated Scheduling and Planning Environment (ASPEN) computer program is a prototype system for developing application programs for automated scheduling. ASPEN is an object-oriented system that contains a modular, reconfigurable, reusable set of software components that implements the elements commonly found in complex automated-scheduling applications. The components include the following:

- An expressive constraint-modeling language that enables the user to naturally define the application domain,
- A constraint-management system for representing and satisfying activity requirements while not violating constraints,
- A temporal-reasoning system for expressing and maintaining temporal constraints,
- A set of search algorithms for generating and repairing schedules, and
- A graphical interface to help the user visualize and modify plans and schedules.

These components can work together

to provide either a fully autonomous command-planning-and-scheduling system, or a mixed-initiative system in which the problem-solving process is interactive. ASPEN is written in C++ using the STL and Leda libraries and the X-Windows environment.

One of the key features of ASPEN is the ability to repair a generated schedule using a search algorithm such as the "iterative repair" technique. Basically, the algorithm iteratively selects a schedule conflict and performs modifications in an attempt to resolve the conflict. The search algorithm automates decisions on what to repair and how to make the repair until all conflicts have been resolved. The iterative repair work builds on the previous NASA Tech Brief, "Software Generates Commands for Operating Remote Instruments," NPO-20085, in this issue.

ASPEN is currently being utilized in the development of an automated planner/scheduler for commanding a naval communications satellite and the New Millennium Program's first Earth-orbiting spacecraft (EO-1) as well as a scheduler for ground maintenance for Highly Reusable Space Transportation (HRST). By automating the command sequence generation process and by encapsulating the operation-specific knowledge, spacecraft commanding can be done by nonoperations personnel, hence allowing significant reductions in mission operations workforce with the eventual goal of allowing direct user commanding (e.g., commanding by scientists).

This program was written by Alex Fukunaga, Gregg Rabideau, Steve Chien, David Yan, Robert Sherwood, and Quoc Vu of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Computer Software category,* ***or circle no. 119*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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Telemetry Management Flight Software

Telemetry Management Flight Software is a computer program designed originally for use in spacecraft, but could also be used in aircraft, balloon-borne instrument packages, or other telemetric instrumentation systems. This program manages telemetric data aboard a spacecraft in a highly configurable fashion. It provides a mission-independent (reusable) means of enabling spacecraft operators to make the most efficient use of low-bandwidth downlink telemetry channels, consistent with standards of the Consultative Committee for Space Data Systems (CCSDS). The program is flexible and makes the spacecraft telemetric system highly commandable. It automatically meters telemetry from multiple sources in a fair manner, on the basis of commanded priorities and bandwidth allocations. Features include automatic retransmission, ring-buffer management, and timed deletions. No other known software offers the particular combination of capabilities and reusability. This program runs under VxWorks on Motorola, MIPS, RAD6000, and other computers. It occupies about 100K of random-access memory.

This program was written by Scott Burleigh and Sanford M. Krasner of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Computer Software category,* ***or circle no. 122*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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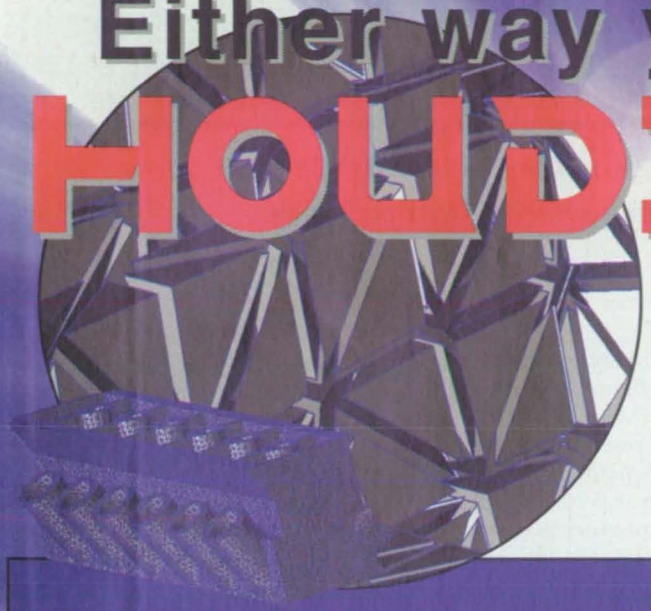

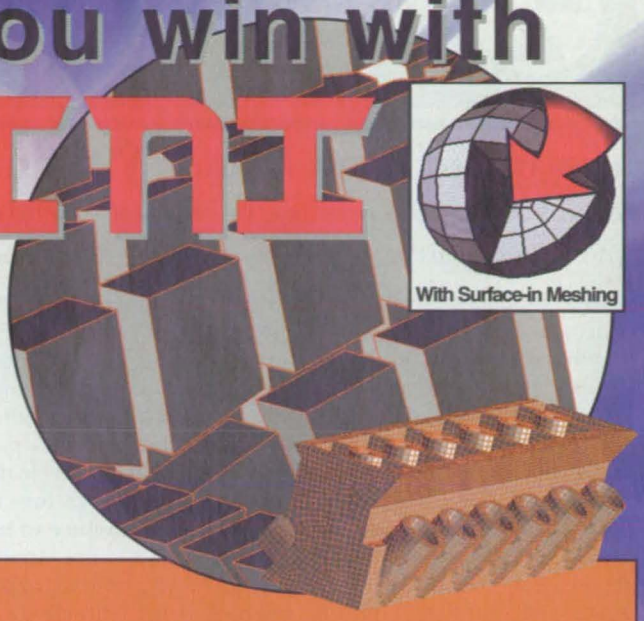

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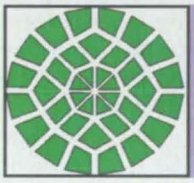
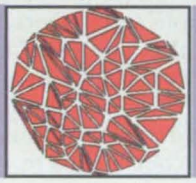
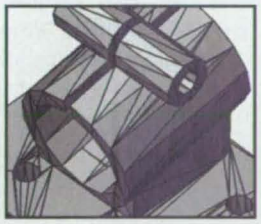
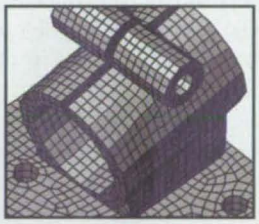


Houdini's mesh generates from the surface in, putting the highest quality elements on the surface.



Other mesh generators work from the inside out, placing lower quality elements at the surface.





2. After the surface mesh is created with Merlin, Houdini meshes your solid model from the surface in and puts the highest quality elements on the surface. This is important because the surface is where you need the best answers: where loads and boundary conditions are applied and stress levels tend to be the highest. For example, if you break a board over your knee, it cracks on the surface first. This principle works with tetrahedral, brick or hybrid models, which have bricks on the surface and tets on the inside.

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Micromachined Planar Vibratory Microgyroscopes

Improved designs promise to increase sensitivity and decrease drift and noise.

NASA's Jet Propulsion Laboratory, Pasadena, California

Micromachined planar vibratory microgyroscopes are undergoing development for use in monitoring the orientations of robots, scientific instruments, and other objects. A device of this type can be fabricated by use of silicon-on-glass or complementary metal oxide/semiconductor (CMOS) bulk-micromachining technology. Because they offer advantages of relatively small size, weight, and power consumption, vibratory microgyroscopes offer attractive alternatives to spinning-mass and optical gyroscopes in such applications.

Like other vibratory gyroscopes, a micromachined planar vibratory microgyroscope is based on a principle similar to that of the Foucault pendulum. First, a vibration is excited in one of two modes of the gyroscope structure. Then the Coriolis force associated with a rotation that one seeks to measure induces a transfer of energy from that vibrational mode to the other one. The vibration in the second mode is measured to obtain data from which the rotation can be inferred.

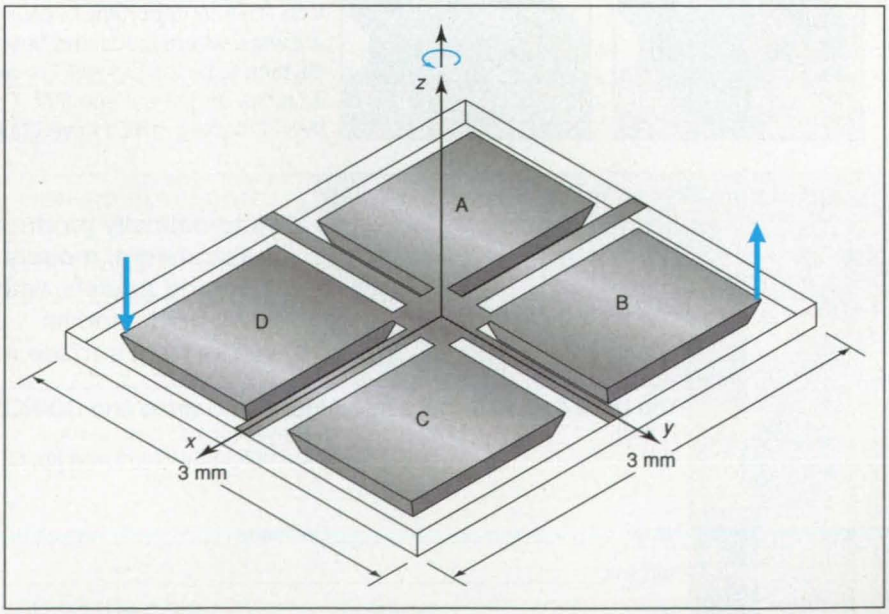
Vibratory microgyroscopes of older design are disadvantageous in several respects. They must be fabricated with extreme precision because their proper functioning depends on precise matching of mechanical resonances. Typical values of their vibrating masses are no greater than about 10^{-10} kg, typical values of their spring stiffnesses are no less than 1 N/m, and their resonance frequencies typically lie between 20 and 30 kHz. At such high resonance frequencies, the amplitudes of vibrations and thus the amplitudes of readouts are small, and consequently sensitivity is low. With such small masses, rates of damping are large. The vibration actuators and vibration-sensing structures have small capacitances, and this also limits sensitivity. The net result of these disadvantageous characteristics is that drift rates can be as large as 5,000°/hour. The improved designs of the developmental micromachined planar vibratory microgyroscopes are intended to reduce drift rates to no more than 10°/hour.

A micromachined planar vibratory microgyroscope (see figure) includes four planar silicon plates connected together in a pattern resembling that of a clover leaf. The plates are suspended by four silicon slab springs. In the absence of input rotation, plates A and C are driven electrostatically out of phase to oscillate in seesaw mode in the z direction.

One seeks to measure rotation about the z axis. When such rotation occurs, the Coriolis force causes the plates B and D to also oscillate in a seesaw mode in the z direction; that is, the Coriolis force causes a transfer of energy from A-C seesaw mode to B-D seesaw mode. The displacements of plates B and D are detected by use of capacitive proximity sensors. These displacements are inversely proportional to the resonance frequency of the output (B-D seesaw) mode and proportional to (1) the amplitude of the input (A-C) displacement, (2) the rate of rotation about the z axis, and (3) the resonance quality factor, which is commonly denoted "Q" and is inversely proportional to the rate of damping.

In fabricating a micromachined planar vibratory microgyroscope, extreme precision for matching of resonances is not necessary. The symmetrical planar structure inherently matches the resonances of the input (A-C) and output (B-D) vibration modes. Typical vibrating-mass values for these devices range from 10^{-6} to 10^{-4} kg, typical spring stiffnesses are about the same as in older microgyroscopes (about 1 N/m or greater), and typical mechanical resonances lie approximately in the frequency range from 100 Hz to 1 kHz.

With these characteristics, micromachined planar vibratory microgyroscopes offer several advantages over older vibratory microgyroscopes: With lower resonance frequencies, outputs are larger. With larger masses, both thermal noise and rates of damping are reduced. The areas of driving and sensing structures are larger, resulting in larger capacitances and thus larger driving forces and larger output sig-



Plates A and D Are Driven to vibrate about the center in a seesaw mode. When the assembly rotates about the z axis, the Coriolis force couples some of the vibrational energy to the seesaw mode of plates B and D. The amplitude of the B-D seesaw mode is measured and used to infer the rate of rotation.

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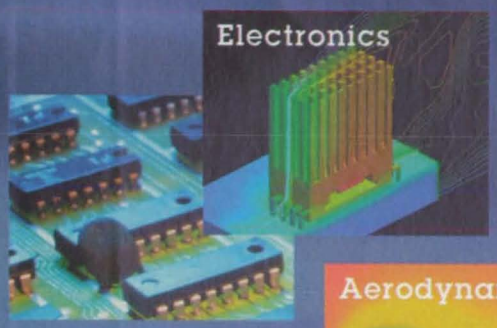

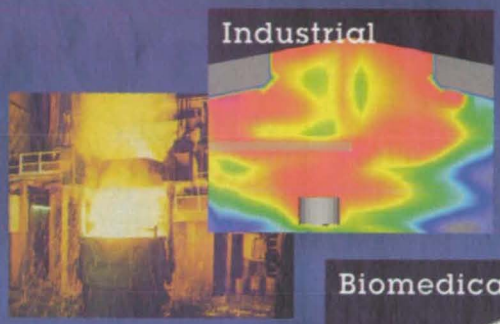

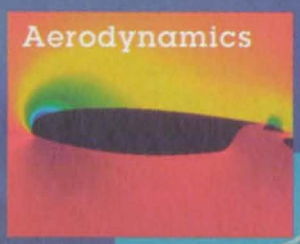

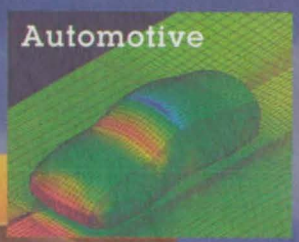

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nals. Moreover, a micromachined planar vibratory microgyroscope can be driven off resonance, eliminating the need for mechanical matching between the input and output modes.

This work was done by William J. Kaiser, Tony K. Tang, and Randall K. Bartman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category,* ***or circle no. 129*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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Refer to NPO-19713, volume and number of this NASA Tech Briefs *issue, and the page number.*

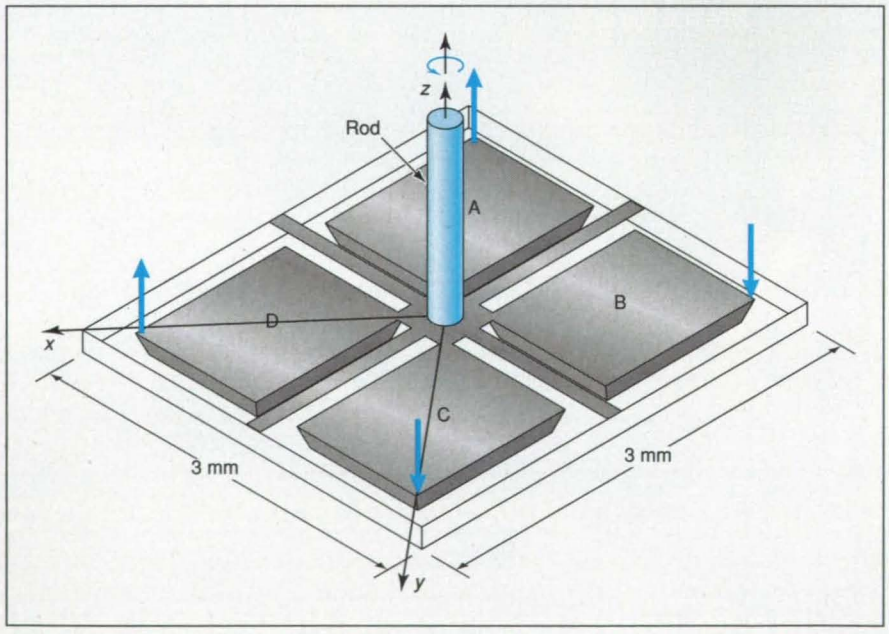
Planar Vibratory Microgyroscope: Alternative Configuration

A rod is attached at the center of the vibrating structure.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure illustrates a micromachined planar vibratory microgyroscope with a configuration like that described in the preceding article, except that a rod between 3 and 4 mm long and oriented along the z axis is attached rigidly to the center of the planar vibrating structure. This device offers the same advantages as do the micromachined planar vibratory microgyroscopes described in the preceding article, plus the additional advantage that the rod contributes to the moments of inertia about the x and y axes, thereby creating a more favorable inertia ratio. It also helps to place mechanical resonances in a desired low frequency range of 0.1 to 1 kHz.

The principle of operation is the same as that described in the preceding article, except that the rod plays an important part in the motion. As before, the purpose of the device is to measure rotation about the z axis. As before, four planar silicon plates are connected together in a pattern resembling that of a clover leaf, and the plates are suspended by four silicon slab springs; however, in this case, the rod is also attached to the central body where the springs and plates come together. As before, plates A and



The Rod Contributes Additional Moment of Inertia about the x and y axes, thereby creating a more favorable inertia ratio and desirably lowering resonance frequencies. In other respects, this device is similar to the devices described in the preceding article.

C are driven electrostatically to oscillate in a seesaw mode in the z direction. This seesaw motion causes the rod to engage in rotational oscillation about the x axis.

In the absence of rotation about the z axis, plates B and D remain stationary. When the device rotates about the z axis, the Coriolis force causes the rod to oscillate somewhat about the y axis, thereby causing plates B and D to also oscillate in a seesaw mode. Thus, when there is rotation about the z axis, the Coriolis force causes transfer of energy from the seesaw mode of plates A and C to the seesaw mode of plates B and D; the amplitude of oscillation in this mode is directly related to the rate of rotation about the z axis. This amplitude is measured capacitively to obtain a measure of the rate of rotation.

This work was done by Tony K. Tang, William J. Kaiser, Randall K. Bartman, Jaroslava Z. Wilcox, Roman C. Gutierrez, Robert J. Calvet, and S. K. Tsang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category,* ***or circle no. 130*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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Modulation/ Detection Technique for Measuring Acceleration

Performances of accelerometers would be enhanced by lock-amplification of superimposed oscillations.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed technique for increasing the signal-to-noise ratios of accelerometers is based on a concept of phase-sensitive detection and amplification of oscillations superimposed on the accelerations that one seeks to measure. The technique would be especially applicable to micromachined spring-and-proof-mass accelerometers and to conventional accelerometers mounted on suitably configured micromachined structures.

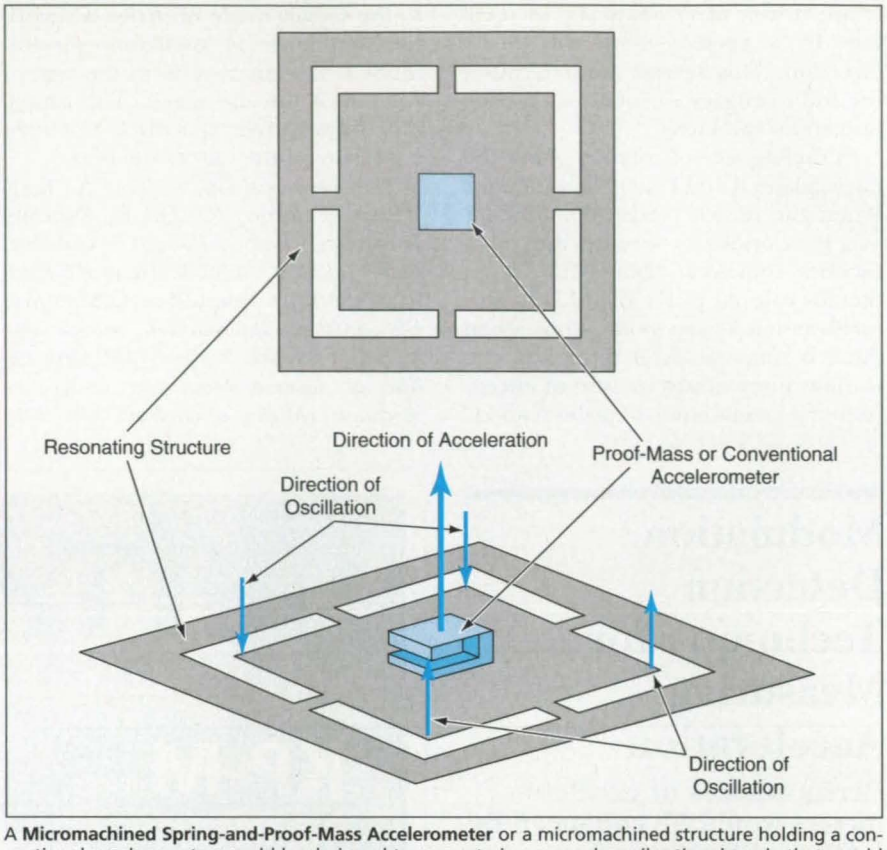
In a conventional spring-and-proof-mass accelerometer, the inertia of the proof mass causes the spring to deflect in a response to an acceleration along one axis. The resulting displacement of the proof mass can be measured by any of several well-known proximity-sensing techniques based, for example, on capacitance, piezoresistance, or quantum-mechanical tunneling of electrons. The acceleration can then readily be calculated from the measured displacement and the known stiffness and inertial properties of spring-and-proof-mass structure.

In an accelerometer designed to implement the proposed technique, the spring structure on which the proof mass or conventional accelerometer would be mounted would include a spring substructure capable of deflec-

tion not only in the primary acceleration-sensing mode but also in a secondary vibration mode with a known resonance frequency and with displacements along the acceleration-sensing axis (see figure). By use of a suitable actuator driven at the resonance frequency, vibrations in this mode would be excited, thereby generating a resonance-frequency component of acceleration superimposed on the acceleration that one seeks to measure.

The use of phase-sensitive detection and amplification to increase signal-to-noise ratios is well known. The basic idea is to detect and amplify only the signal component at a specific known frequency and phase, thereby rejecting noise that occurs over a broad range of frequencies. In the proposed technique, phase-sensitive detection and amplification would be accomplished by processing the output of the displacement sensor through a lock-in amplifier that would be phase-locked to the oscillator used to excite the secondary vibrations.

This work was done by Tony K. Tang and Michael H. Hecht of Caltech for **NASA's Jet Propulsion Laboratory**. *No further documentation is available.*
NPO-20049



A **Micromachined Spring-and-Proof-Mass Accelerometer** or a micromachined structure holding a conventional accelerometer would be designed to resonate in a secondary vibrational mode that would be in addition to the primary acceleration-sensing mode. The secondary vibrations would be exploited in a phase-sensitive-detection scheme to increase the sensitivity to acceleration.

Micromachined Planar Vibratory Sensors With Mode Matching

Sensitivity would be increased by exploiting two resonances at the same frequency.

NASA's Jet Propulsion Laboratory, Pasadena, California

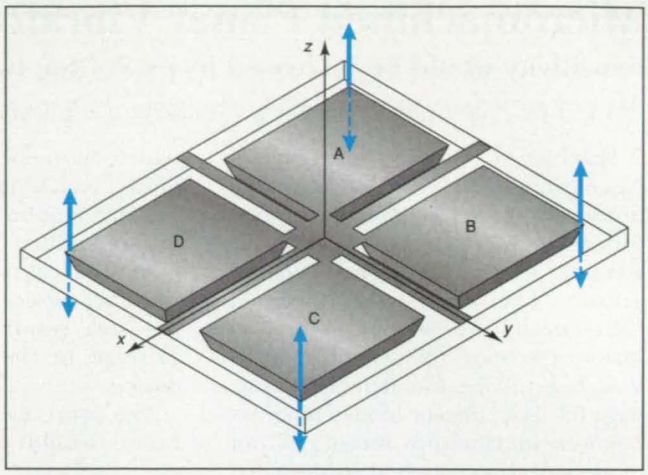
Matching of the resonance frequencies of vibrational modes has been proposed as a means to enhance the performances of micromachined planar vibratory sensors and, in particular, of sensors like those described in "Micromachined Planar Vibratory Microgyroscopes" (NPO-19713), *NASA Tech Briefs*, to be found in this issue, page 68. The concept of matching resonances in vibratory sensors is not entirely new; as reported in the cited prior article, this concept is essential to the proper functioning of vibratory microgyroscopes of older design. What is new about the present proposal is taking advantage of both the mode-matching concept and the inherent advantages of micromachined vibratory sensors to achieve unprecedented degrees of responsivity.

To recapitulate from the cited prior article: a typical micromachined planar vibratory microgyroscope (see figure) includes four planar silicon plates connected together in a pattern resembling that of a clover leaf. The plates are suspended by four silicon slab cantilever springs. Plates A and C are driven electrostatically out of phase to oscillate in rocking (see-saw) mode in the z direction. In the absence of other disturbances, plates B and D remain stationary.

One seeks to measure rotation about the z axis. When such rotation occurs, the Coriolis force causes plates B and D to also oscillate in a rocking mode in the z-direction; that is, the Coriolis force causes a transfer of energy from A-C (input) rocking mode to the B-D (output) rocking mode. By use of capacitive proximity sensors, the displacements of plates B and D are measured to obtain data from which the rate of rotation can be inferred.

The mode-matching concept involves the following reasoning: If plates A and B were driven at the resonance frequency of the A-B rocking (input) mode, the A-B rocking motion would effectively be amplified by the resonance quality factor (Q) of that mode. If plates A through D and their supporting cantilever springs were fabricated precisely with four-fold symmetry in the x–y plane, then the two rocking modes would have the same shape, would be oriented orthogonally to each other in the x–y plane, and would have equal resonance frequencies. Because of this mode matching, the B-D (output) rocking motion would also be effectively amplified by Q. Inasmuch as the Q of a typical micromachined silicon vibratory device can exceed 50,000, the net result would be a large increase in the responsivity of the device.

The precisely symmetrical configuration would offer two additional advantages. First, the resonating structure would be perfectly balanced, with a fixed center of gravity where the sum of forces and moments resulting from vibrations in the two modes could be zero. This would make for low dissipation of energy and thus high Q. The second advantage would be that perfect symmetry would preclude differential thermal expansion and thereby preserve the



Symmetry Would Result in Degeneracy (that is, equality of resonance frequencies) of the A-C and B-D rocking (seesaw) vibrational modes, which would be coupled slightly by the Coriolis acceleration associated with rotation about the *z* axis. As a result of the mode matching, both modes would be effectively amplified by *Q*.

degeneracy of the two vibration modes at all temperatures.

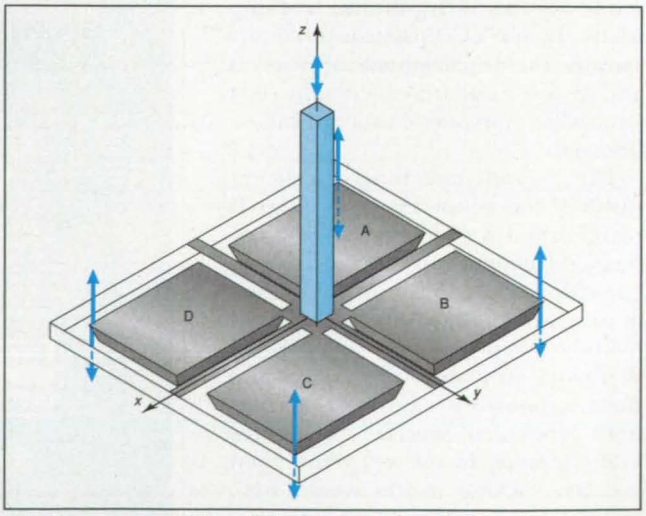
This work was done by Tony K. Tang, William J. Kaiser, and Roman C. Gutierrez of Caltech for **NASA's Jet Propulsion Laboratory**. *No further documentation is available.*
NPO-20048

Micromachined Silicon Vibratory Three-Axis Accelerometer

Several advantageous features would be combined in a single device.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure illustrates a proposed micromachined vibratory three-axis accelerometer. This device would include a micromachined silicon vibratory substructure in the *x*–*y* plane, similar to that described in the second of the two preceding articles, "Micromachined Planar Vibratory



This **Micromachined Silicon Vibratory Device** could be used to measure acceleration along the *x*, *y*, and *z* axes.

Sensors With Mode Matching" (NPO-20048). In addition, a rigid rod oriented along the z axis would be attached to the center of the vibratory substructure. This device would superficially resemble the rotation-sensing device described in "Planar Vibratory Microgyroscope: Alternative Configuration" (NPO-19714), *NASA Tech Briefs*, to be found in this issue, page 70, but its design would be optimized for sensing translational acceleration instead of rotation.

Electrodes for electrostatic excitation of vibrations and other electrodes for capacitive sensing of vibrational displacements of plates A, B, C, and D would be located under these plates. All four plates and the rod would be driven synchronously at the resonance frequency of the fundamental z-axis vibrational mode of the structure. To enhance the signal-to-noise ratio, the capacitance readings would be taken with the help of lock-in amplifiers synchronized by the resonant vibration-exciting signal as described in the first of the two preceding articles, "Modulation/Detection Technique for Measuring Acceleration" (NPO-20049).

In the presence of a positive acceleration along the x or the y axis, the rod would tilt toward the negative x direction or negative y direction, respectively, giving rise to a corresponding tilt of plates A through D. In turn, the tilt of the plates would result in a change in the oscillatory capacitance readings, which could be processed into x-axis or y-axis acceleration via predetermined relationships among accelerations, tilts, and capacitances. For acceleration along the z axis, similar considerations would apply, except that the rod would not tilt; instead, the rod would function as a simple proof mass, and the capacitance readings for all four plates would be indicative of the common z-axis oscillation superimposed on the z-axis acceleration.

The proposed accelerometer would offer several advantages beyond those explicitly stated above:

- Like micromachined accelerometers in general, this one would have a long operational life and could be made to have relatively large masses suspended by relatively soft springs, with resultant low resonance frequencies and large responses with low damping and low thermal noise.
- The four plates and the space underneath them provide ample surface area for electrostatic-excitation and capacitive-displacement-sensing electrodes; this makes it possible to obtain larger capacitance signals and to use smaller excitation voltages than would otherwise be practical.
- Like other micromachined devices with electrostatic deflection, this device would consume very little power.
- Like micromachined devices in general, this device would be compact and amenable to mass production at low cost per unit.

With design parameters chosen to take maximum advantage of these characteristics, it should be possible to manufacture devices of this type to measure accelerations as small as about 10^{-8} m/s^2.

This work was done by Tony K. Tang, Roman C. Gutierrez, Wen J. Li, Christopher Stell, Jaroslava Wilcox, and William J. Kaiser of Caltech for **NASA's Jet Propulsion Laboratory**. *No further documentation is available.*
NPO-20047

Miniature Instrumented Robotic Vehicles for Exploration

Components would perform multiple functions, maximizing utilization of mass.

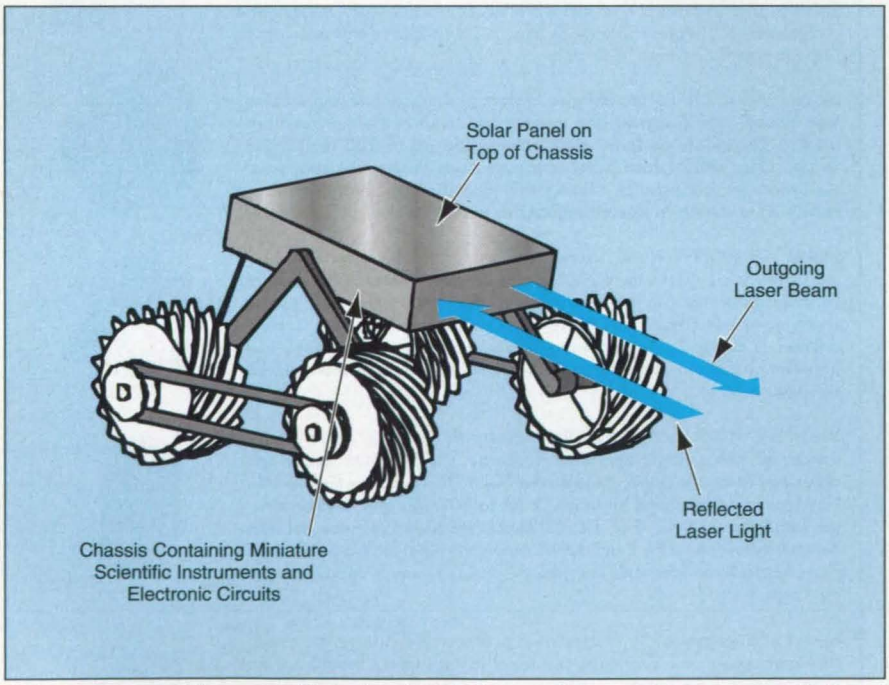
NASA's Jet Propulsion Laboratory, Pasadena, California

Toy-sized, instrumented, automated or remotely controlled robotic vehicles called "nanorovers" have been proposed for use in exploration of Mars and the moons of the outer planets. Terrestrial versions could be devised for such uses as monitoring toxic waste dumps and exploring terrain in harsh environments like those in craters of volcanoes and in polar regions. It should also be possible to build simplified toy versions.

These nanorovers would differ from the ones described in "Tetherless, Optically Controlled Nanorovers" (NPO-19606), *NASA Tech Briefs*, Vol. 21, No. 3 (March 1997), page 92. The nanorovers according to the present concept would feature four-wheel drive actuated by miniature commercially available gearmotors, with rocker bogie suspensions (see figure). A nanorover would incorporate several scientific instruments plus all necessary power, communication, and control electronic circuitry. The scientific instruments could include a video camera with a focusing mechanism to accommodate a range of distances and resolutions, a point scanning infrared spectrometer and a mass spectrometer for identifying materials in rocks or other nearby objects, and several laser diodes that emit at different wavelengths.

Despite the multiplicity of instruments and functions, the overall dimensions of a typical nanorover would be only a few centimeters, and its overall mass would be of the order of 100 g. Such an extreme combination of miniaturization and versatility would be achieved by utilizing the best commercially available components and materials in an advanced design in which structures and functions that have traditionally been designed according to different disciplines and assigned separate functions would be combined and intercoupled. In other words, each structural component, each electronic component, each actuator, and each sensory component would be designed to perform as many different functions as possible so that mass and size allowances would not be used up any more than necessary. This concept of multiple functionality is best explained by the following examples:

- The main structural components of the vehicle chassis would be two printed-circuit boards, between which all electronic circuitry would be mounted. These boards would also serve as a bench for the scientific instruments, and the top surface of the upper board would serve as a platform for solar photovoltaic cells.
- The mechanism for adjusting the camera focus would also be used to scan the infrared spectrometer over its wavelength range.
- The laser diodes would provide excitation for the spectrometer. Reflected laser light would also provide feedback for a piezoelectric actuator for fine adjustment of a spectrometer slit. One of the laser diodes operating at more than its usual power would be used to vaporize surface material from a rock or other object to expose fresh, uncontaminated underlying material for analysis by the infrared spectrometer. Alternatively or in addition, vaporized material could be analyzed by the mass spectrometer.
- Being tilted with respect to the local terrain, the panel of solar cells would generate maximum power when aimed in azimuth approximately toward the Sun. Thus, in addition to generating power, the solar panel would provide an approximate direction reference for navigation. For this purpose, the navigation routine would include occasional pirouettelike maneuvers.



A **Nanorover**, resembling a toy all-terrain vehicle in shape and size, would feature a sophisticated mass- and space-efficient design for implementing multiple scientific, navigation, and control functions.

This work was done by Brian Wilcox, Annette K. Nasif, Michael A. Newell, Jan A. Tarsala, and Sarita Thakoor of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category,* ***or circle no. 101*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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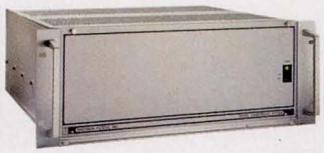

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Setup for Multidirectional Wire EDM

Large workpieces can be cut along multiple planes.

Marshall Space Flight Center, Alabama

An apparatus for wire electrical-discharge machining (EDM) includes a compound-pulley mechanism for routing the wire in various directions, making it possible to cut a workpiece in multiple planes, one plane at a time. For example, when set up as shown in the figure, the apparatus can be used to cut through the wall of the workpiece along a horizontal plane that starts out as a wire line tangent to the round outer surface of the workpiece at the desired height. During EDM, the workpiece can be rotated about its vertical axis by use of a turntable, so that the cut through the wall can be extended along the entire circumference, without cutting any parts inside the workpiece.

The pulley spools are made of electrically insulating material (nylon). The pulleys are parts of a mechanism that holds the wire in the specified position and at the specified tension. The wire is longer than that used in typical other EDM apparatuses and excessive voltage drop could arise from EDM current flowing in the longer wire. Therefore, it is desirable to supply the current as close as possible to the cutting location; this is done by making electrical contact between the wire and the source of EDM power not only at an end of the wire but also via carbide blocks, called "energizers," against which the wire brushes at several locations.

This work was done by Gary N. Booth, R. Michael Malinzak, and Gareth L. Simpson of Rockwell International Corp for **Marshall Space Flight Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Manufacturing/Fabrication category,* ***or circle no. 107*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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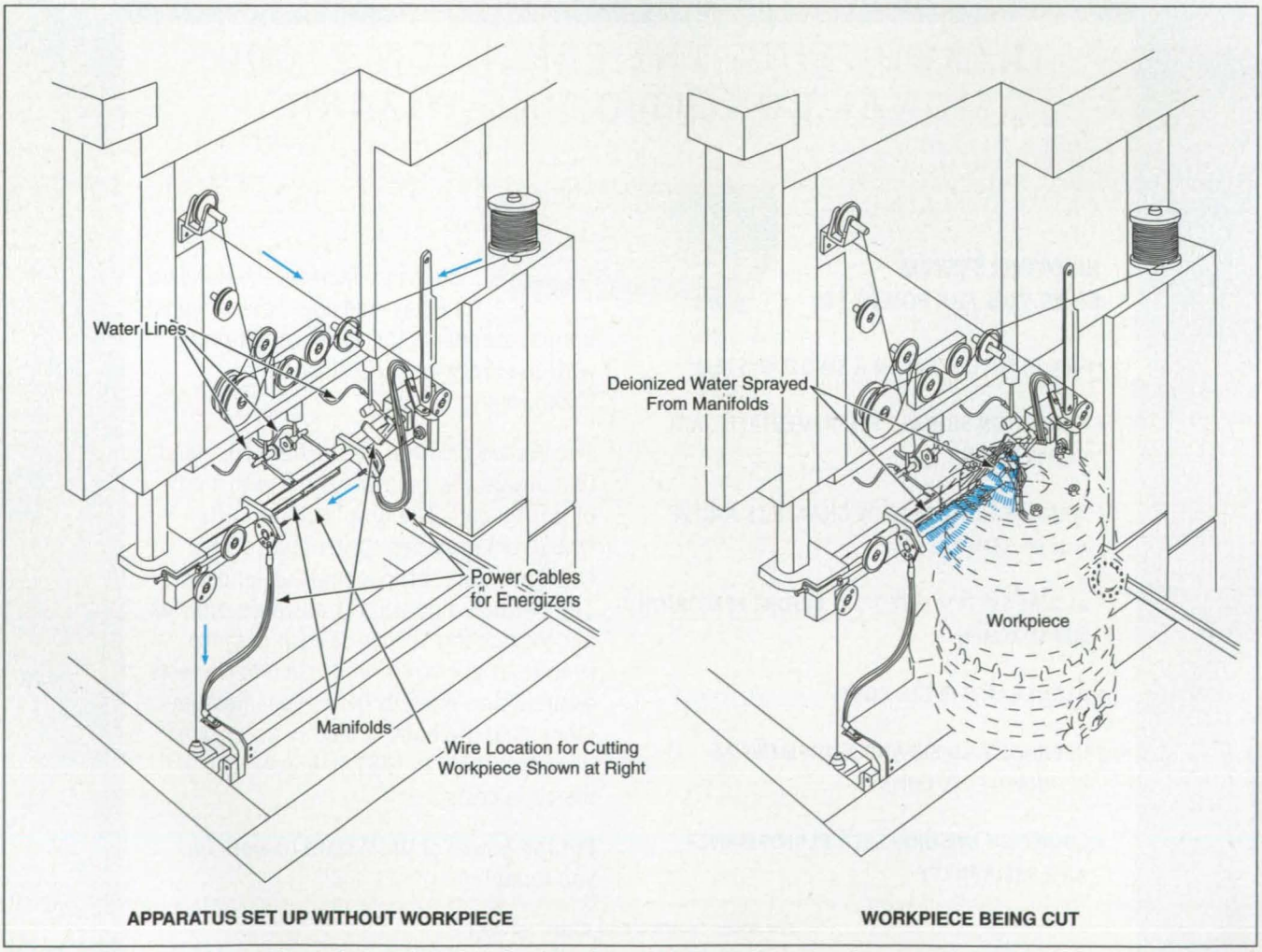

Multiple Pulleys are used to position and orient the wire in the plane along which the workpiece is to be cut. In this case, the workpiece (a turbopump) is rotated continuously past the cutting location on the wire. The sprays of deionized water cool the workpiece.

Noncontact Automatic Standoff Control for Arc Welding

The standoff distance would be monitored optically.

Marshall Space Flight Center, Alabama

A proposed noncontact method of automatic standoff control (ASOC) for arc welding is based on optical monitoring of the standoff distance; that is, the distance between the welding torch and the workpiece. Two previously reported methods of ASOC involve the use of mechanisms in contact with the workpiece [see "Automatic Stand-Off Control for Arc Welding" (MFS-26294), *NASA Tech Briefs*, Vol. 20, No. 9 (September 1996), page 90]. All of these methods of ASOC have been investigated in efforts to find alternatives to an older automatic-voltage-control (AVC) method, which was found to be unsatisfactory because the welding-arc voltage is not simply proportional to the standoff distance, but can fluctuate even when the standoff distance remains constant, and can give a false distance reading at startup.

In the proposed noncontact method of ASOC, an industrial laser displacement sensor would be installed on the welding-torch assembly and used to monitor the standoff distance. The sensor could be, for example, a commercial unit that measures displacement relative to a reference distance, generating an analog output signal indicative of the displacement every millisecond. The unit is designed to be capable of measuring to a resolution of 2 μm within a range of ±5 mm about a reference distance. The displacement output of the sensor can be set to zero at the reference distance.

The output of the sensor would be processed through a proportional+integral+derivative (PID) signal-processing circuit in an automatic-welding-control system (AWCS) to obtain a feedback control signal for adjusting the height of the welding torch above the workpiece. Because the AWCS was designed for AVC, original PID parameters were chosen to optimize the response of the torch-positioning servocontrol subsystem to the arc voltage. In implementing the proposed method, it would be necessary to modify the PID parameters to optimize the response to the output of the laser displacement sensor. It has been estimated that this method would enable control of the standoff distance to an accuracy of 0.007 in. (0.18 mm).

This work was done by Richard Venable of Lockheed Martin for **Marshall Space Flight Center.** *For further information, access the Technical Support Package (TSP)* ***free-on-line at www.nasatech.com*** *under the Manufacturing/Fabrication category,* ***or circle no. 111*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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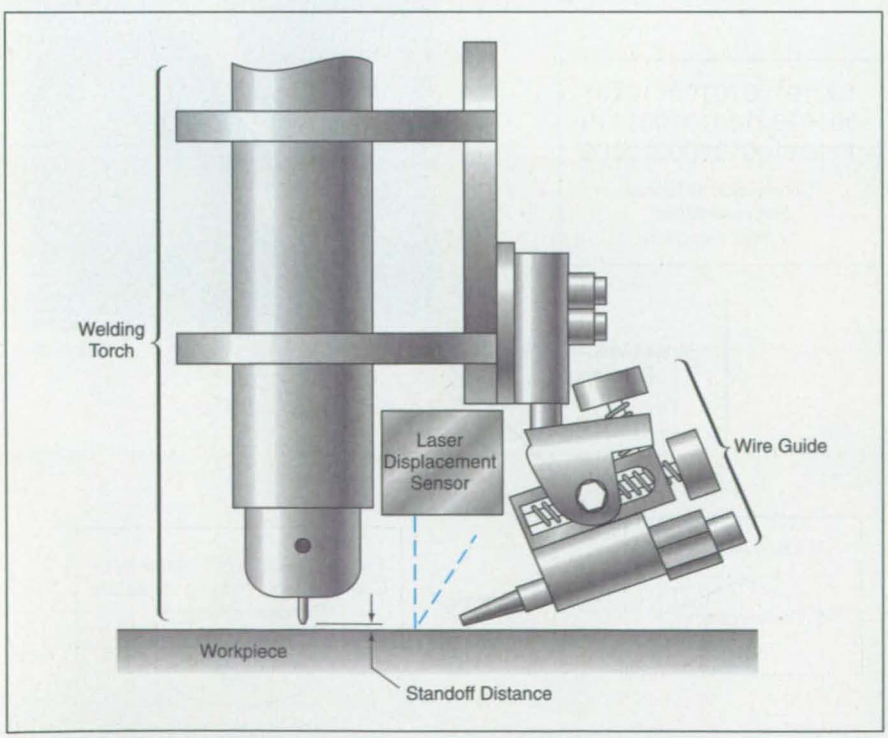


A **Laser Displacement Sensor** would monitor the standoff distance, providing a feedback signal for maintaining the standoff distance within a narrow range.

Using Machine Learning To Study Aircraft Control Stability

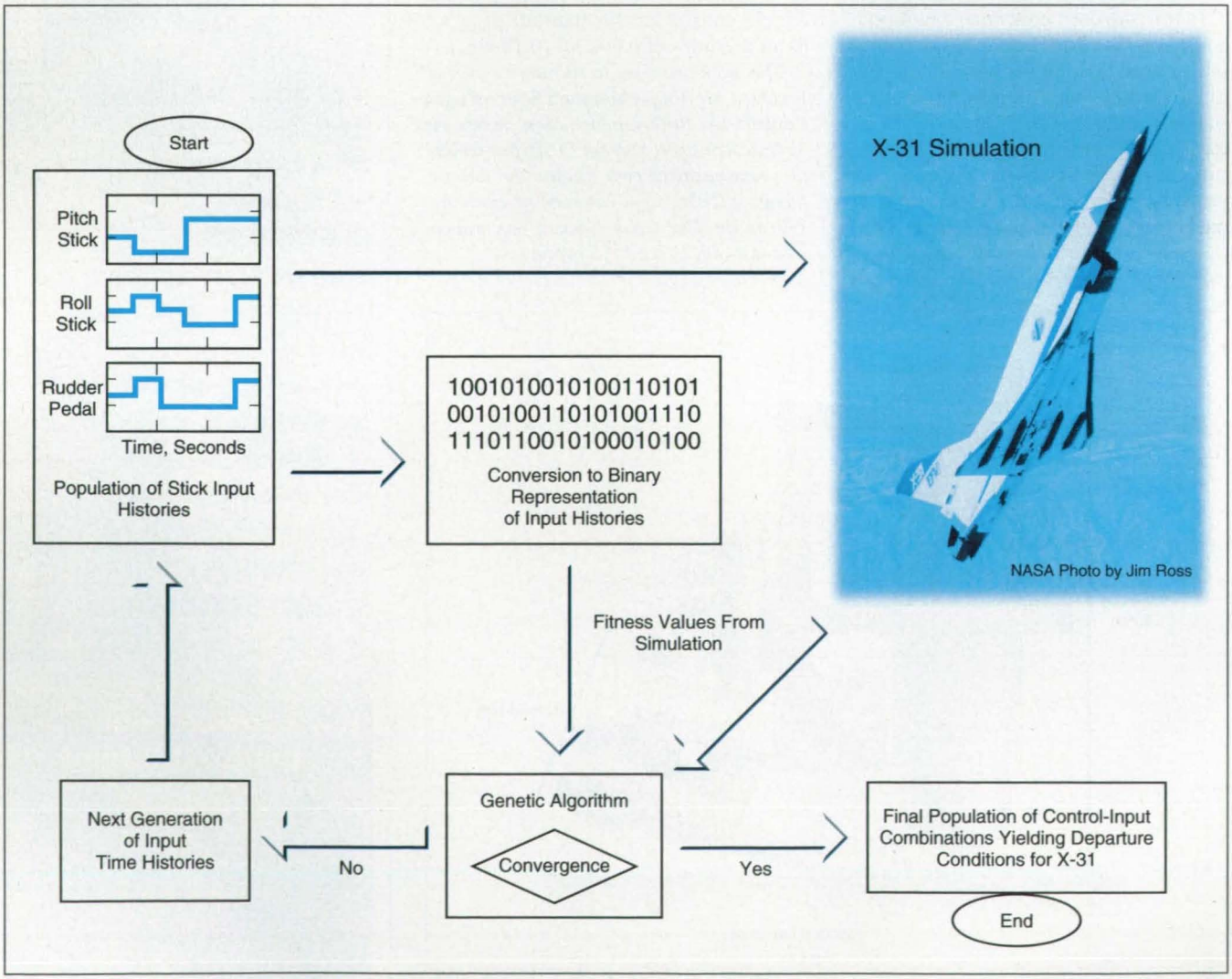
Dynamical simulations are performed and analyzed in a genetic-algorithm-based search.

Dryden Flight Research Center, Edwards, California

Machine learning techniques have been utilized in research on flight-control stability and instability in advanced fighter-type airplanes. To give meaning to a description of this research, it is necessary to define some terms: In this context, "departure" signifies instability and/or uncontrollability in the response of an aircraft to flight-control actions at a given flight condition; "departure susceptibility" means susceptibility of an aircraft to departure — that is, to flight-control instability and/or uncontrollability; and "departure resistance" signifies resistance to departure — that is, stability and controllability in the response of an aircraft to flight-control actions at a given flight condition.

Departure-resistance testing of such highly complex and maneuverable aircraft as modern fighters is difficult and presents a challenge for engineers. As aircraft have become more complex and maneuverable, departure susceptibility has increased. Increases in the complexity of aircraft systems have also made it more difficult to "wring out" these systems to find potential pitfalls; this is evidenced by the number of incidents in the recent history of modern fly-by-wire aircraft. To ensure a level of safety, a typical aircraft is flown within a safe margin of conditions that could lead to a departure, reducing the available maneuvering envelope (the allowable limits of control actions, velocities, and altitudes during maneuvers) of the aircraft. Such margins of safety are found by performing simple, single-parameter static- and

Continued on page 82



The **Computational Departure-Resistance-Evaluation Process** consists mostly of a genetic-algorithm-based search among dynamical simulations — in this case, simulations of responses of the X-31 airplane to various combinations of time-varying control inputs.

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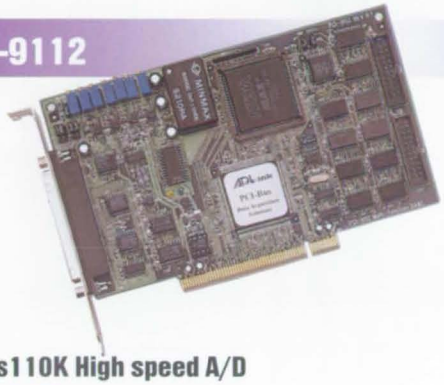

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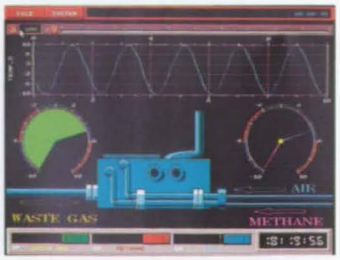

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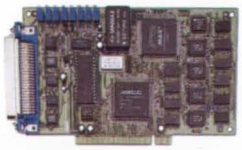

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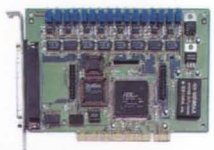

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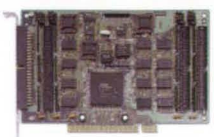

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- Programmable interrupt handling
- Output status readback
- Compact size PCB
- AT IRQ Level: IRQ3~IRQ15

PET-48DIO
- On board Internal time trigger
- 48 TTL/DTL DIO channels
- Direct interface with Opto-22 compatible I/O module
- Emulates 2 8255 PPI mode 0
- Buffered circuits for high driving
- Programmable interrupt handling
- Output status readback
- Compact size PCB
- AT IRQ Level: IRQ3~IRQ15

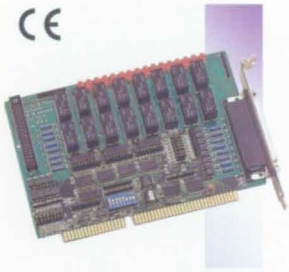
ACL-7120
- 32 TTL digital inputs
- 32 TTL digital outputs
- High output drive and low input loading
- 6 independent 16-bit down counters
- Internal/External interrupt generation
- Crystal based frequency source
- Breadboard area for customized circuits

ACL-7124
- 24 TTL/DTL DIO channels
- Direct interface with Opto-22 compatible I/O module
- Emulates 8255 PPI mode 0
- Buffered circuits for high driving
- Programmable interrupt handling
- Output status readback
- Compact size PCB
- IRQ Level: IRQ2~IRQ7

CE

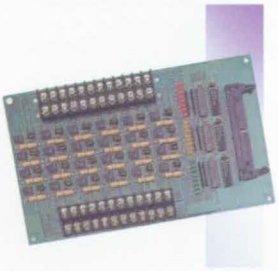
ACL-7125
- 8 relay actuator outputs
- 8 opto-isolated digital inputs
- LED indicates the relay status
- AC/DC isolated input
- On-board relay driving circuits
- 37-pin D-SUB type connector

CE



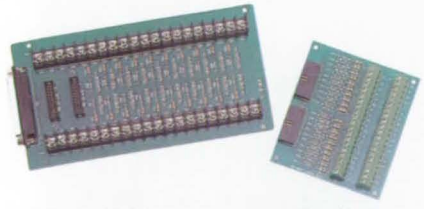
ACL-7225
- 16 relay actuator outputs
- 16 opto-isolated digital inputs
- LED indicates the energized relay
- AC/DC isolated input
- 1,000Vdc fully isolation
- On-board relay driving circuits
- 37-pin D-SUB type connector

TB-24R
- 24 SPDT relays
- 50-pin opto-22 compatible connection
- 220VDC/250VAC switch voltage
- LEDs indicate relay status
- 12V & 24 coil voltage versrion

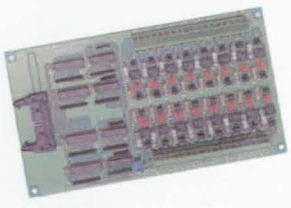


TB-24P
- 24 opto-isolated digital inputs
- 50-pin opto-22 compatible connection
- Threshold from 3VDC to 24VDC
- 2500 V opto-isolation
- Isolation or dry contact selectable
- LEDs indicate input status

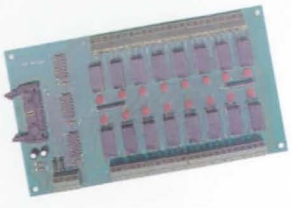
Daughter Boards



ACLD-9188 ACLD-9178
- Universal Screw Terminal Board
- Blank pads for signal condition circuits
- 20-pin rabin or 37-pin D-Sub Connectors
- Dimension:
  211(L) x 115(W)mm (ACLD-9188)
  102(L) x 114(W)mm (ACLD-9178)



ACLD-9182
- 16 Opto-isolated digital inputs
- AC or DC polarity-free digital input
- LED indicates input status
- 20-pin ribbon connector



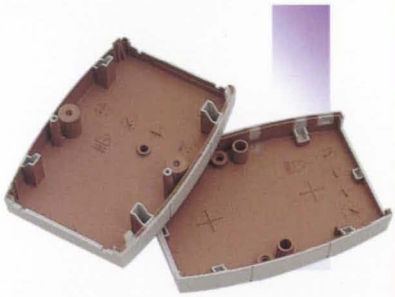
ACLD-9185
- 16 SPDT relay outputs
- On-board relay driver circuitry
- LEDs indicated relay status
- Screw terminal for easy wiring

NuDAM — The Optimal Choice for Harsh Environments

Watch-Dog Timer Inside

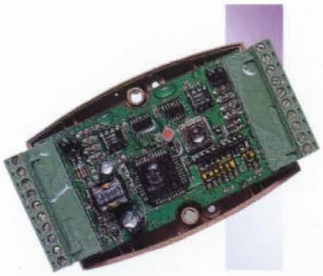
A watch-dog supervisory circuitry can automatically reset the NuDAM modules when the system fails. In addition, a user-programmable software timer provides "safe" output signal in the event of host computer and communication failure.

Noise Immunity
–Electrode for Noise Reduction



An electrode is coated inside the ABS case of the module, which can improve radio-frquency (FRI) and electromagnetic (EMI) noise reduction.

Noise Immunity
–Surface Coating



A surface coating to protect and prolong the life of the PCB, thick-file circuit and electronic components. It allows superior resistance to advance environmental conditions, including humidity, salt spray and most harsh chemicals.

CE

ND-6520:
RS-232 to RS-485 Converter

- Input : RS-232
- Output : RS-485
- Speed : 1200, 2400, 4800, 9600 19.2K, 38.4K (bps)
- Isolation Voltage: 500 Vrms

CE

ND-6510:
RS-485 Repeater

- Input : RS-485
- Output : RS-485
- Speed : 1200, 2400, 4800, 9600 19.2K, 38.4K (bps)

CE

ND-6011:
Thermocouple input module

- Analog Input type: T/C, Voltage, Current
- Thermocouple Type: J, K, T, E, R, S, B
- Voltage Range: +/-15mV, +/-50mV, +/-100mv, +/-500mV, +/-1V, +/-2.5V
- Current Range: +/-20mA
- Smapling rate: 10 samples/sec

CE

ND-6012:
Analog Input Module

- Analog Input type: Voltage, Current
- Voltage Range: +/-150mV, +/-500mV +/-1V, +/-5V, +/-10A
- Current Range: +/-20mA
- Accuracy: 0.05% or better
- Smapling rate: 10 samples/sec

CE

ND-6060:
Relay Outputs & Isolated Input Module

- 4-CH Relay Outputs (2 Form C and 2 Form A)
- Contact Rating: AC 0.6A/125V 0.3A/250V DC 2A/30V, 0.6A/110V
- ON/OFF Interval Time: 3ms/1ms
- 4-CH Isolated Input
- Common External Voltage: +24V

CE

ND-6017:
8 CH Analog Inputs Module

- 6 Differential & 2 Single-ended
- Input Range: ±150mV, ±500mV, ±1V, ±5V, ±10V, ±20mA
- Sampling Rating: 10 samples/ Sec.
- Accuracy: 0.1%

CE

ND-6050:
Digital I/O Module

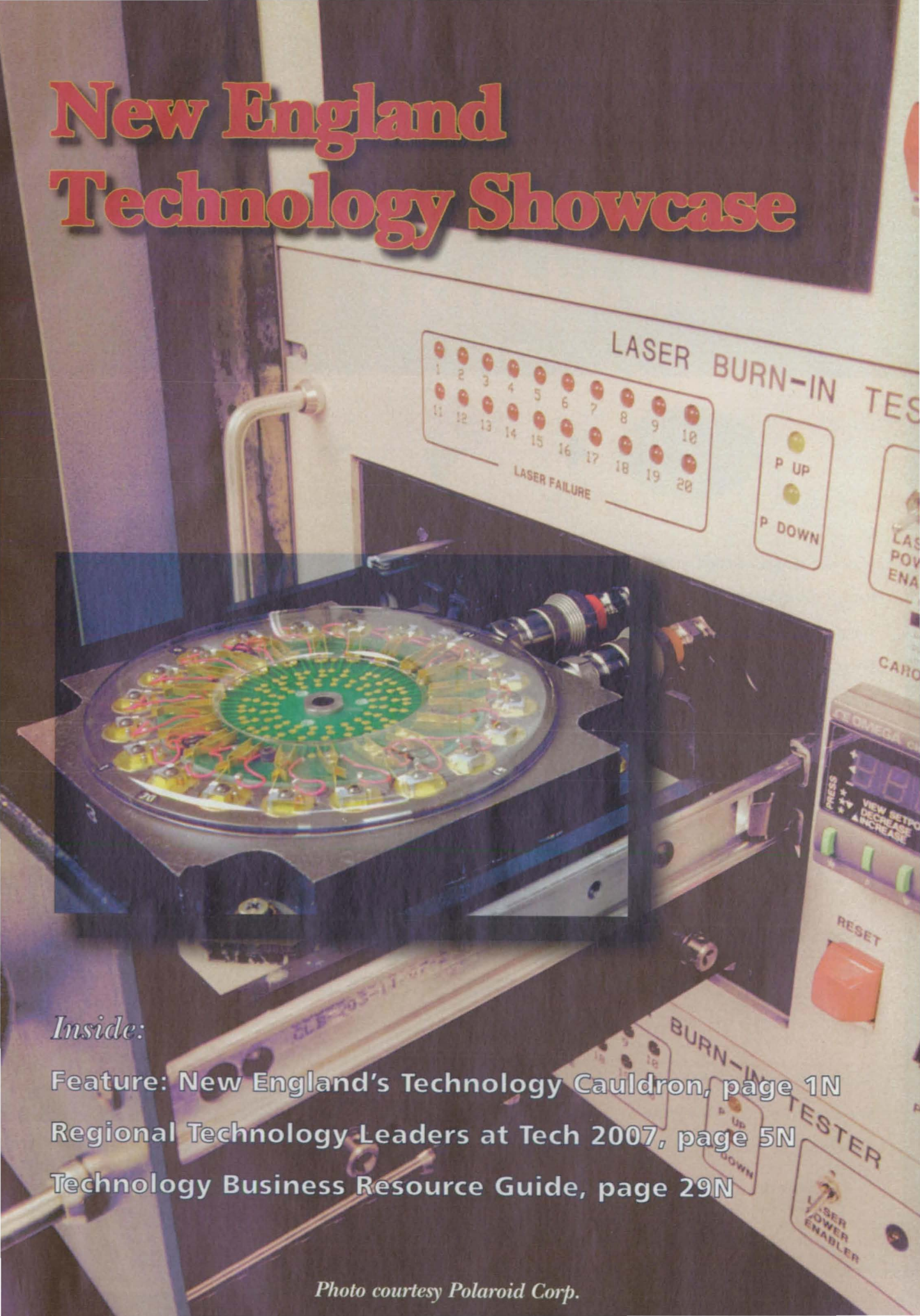
- Digital Inputs: 7 channels
- Switching Level: Low: 1V (max.) High: 3.5V~30V
- Pull-up current: 0.5mA
- Digital Output: 8 channels
- Open collector to 30 V, 30mA max. load

CE

ND-6021:
Analog Output Module

- Voltage output: 0~10V
- Current output: 0-20mA, 4-20mA
- Output Isolation: 1500 VDC
- Resoultion: 12-bit
- Accuracy: ±0.1% or FRS (current) ±0.2% or FRS (voltage)
- Bandwidth: 100 samples/sec

New England Technology Showcase



Inside:

Feature: New England's Technology Cauldron, page 1N

Regional Technology Leaders at Tech 2007, page 5N

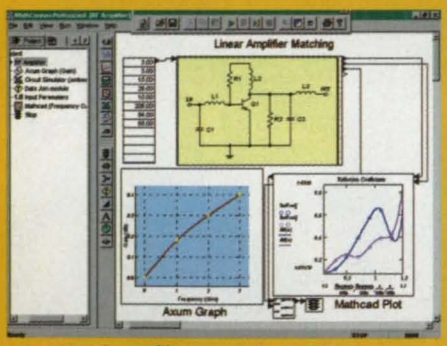
Technology Business Resource Guide, page 29N

Photo courtesy Polaroid Corp.

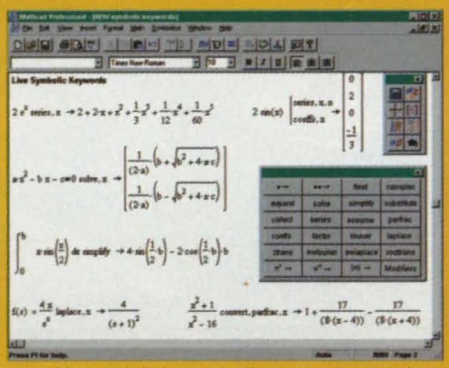
What makes new Mathcad® 7 the world's most innovative calculation software? Let's talk addition.

MORE POWER + EASIER TO USE + TOTALLY WIRED

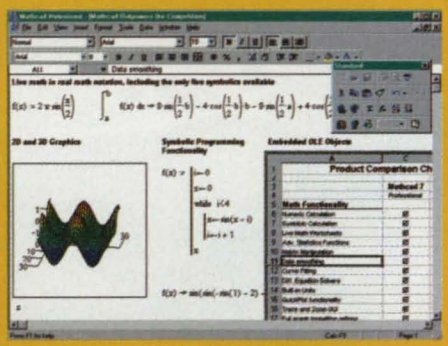
How did simple addition make Mathcad 7 exponentially better? Consider what was added. Like increased power. A more refined interface. Easier equation editing. A richer programming environment. Greater access to deep technical content. And full Web integration — with Microsoft® Internet Explorer built right in. All these additions let corporate workgroups increase productivity — so it's no wonder Mathcad continues to be the world's best-selling calculation software for technical professionals. Looks like the best just got better.



New MathConnex™ gives you the flexibility to combine components from several applications, such as Excel or MATLAB™, in a fully functional system. Feed the frequency output to a Mathcad plot or the gain curve to Axum®. Wire them together and show your entire model working in one window.



New symbolic keywords allow you to descriptively show the operations you perform. Convert an expression to a partial fraction and Mathcad's self-documenting nature explains what you're doing. As always, Mathcad's calculations are live: make a change and your answers are recalculated instantly.



Full support for OLE 2 including automation allows you to drag-and-drop Excel objects into Mathcad and make them functional components, or embed Mathcad objects in your spreadsheet.

To upgrade call **1-888-568-0951**. To order Mathcad 7, visit us at **www.mathsoft.com/mathcad** or see one of these fine retailers.

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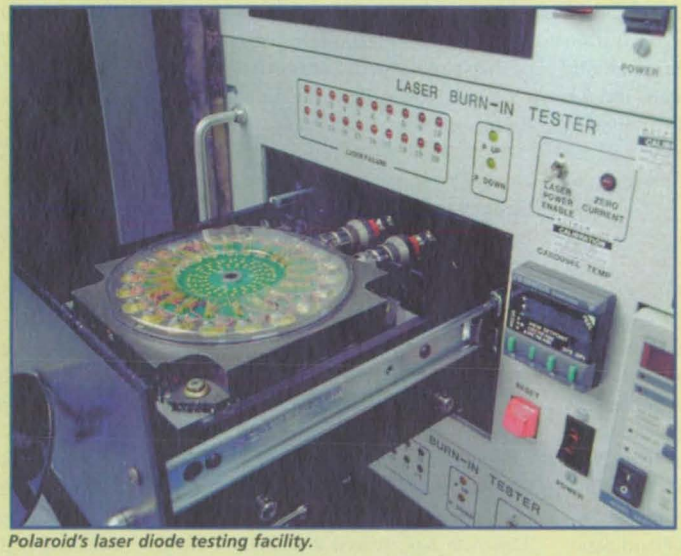
NEW ENGLAND: TECHNOLOGY CAULDRON

The region's high-technology business thrives on cooperation between industry, academia, and Federal and state resources.

Most people in the industrial and business worlds know of Boston's "high technology rings," Routes 128 and 495, close to which are clustered many of the pivotal companies in the nation's technological development and manufacturing community. But few are aware of just how significant high technology is to the New England region as a whole. In a recent study, done by the Connecticut Technology Council (CTC) and based on nine national regions as defined by the U.S. Bureau of Labor Statistics, the New England region had the highest percent of employment in technology-based industry of any national region (14.2% of its total work force). New England's workers are even more concentrated in technology-based businesses than regions that are popularly considered high-tech, such as California, Washington, and Oregon, the study indicates. New England too has 2.5% more employment in technology-based business than the national average (11.7%).



Polaroid's laser diode testing facility.

New England also has close to the highest percentage of firms engaged in technology-based manufacturing, service, and communications businesses, the study shows. Ranked second just slightly behind the Southwest, New England's firms so engaged amount to 6.99%, compared to 7.03% in the Southwest. This is higher than either the Pacific or the Great Lakes regions (both at 6.45%), and distinctly higher that in the Mid-Atlantic region (5.8%).

In today's business climate, with states and localities vying to attract growth industries and high-technology startups, New England's business leaders, legislators, and academicians are hard at work putting together programs to keep the region's high-tech jobs and to create others. An important active group is the New England Council, a partnership of businesses, public agencies, universities, hospitals, and nonprofit organizations throughout the region. Its primary mission is to identify and support public policies and programs that will stimulate sustained economic growth, such as international trade, technology, and defense conversion. The Council coordinated efforts with New England public- and private-sector leaders on NAFTA, GATT, national securities litigation reform, and the R&D tax credit. In addition to a Boston office, the Council is the only New-England-wide business group with a full-time office on Capitol hill in Washington.

Similar support is rendered by the Center for Technology Commercialization, a not-for-profit corporation that assists industry to obtain and commercialize NASA-, defense-, industrial-, and university-developed technologies. Its mission is to make American companies more competitive worldwide through market-driven product and process definition, technology acquisition, and product commercialization. Since its inception in 1992, the Center has established four new companies, licensed 19 NASA and Federally funded technologies to private industry, completed 33 partnership agreements between Federal labs and private companies, and assisted small businesses in raising more than $3 million in capital, among other things.

Connecticut

Connecticut Innovations Inc. (CII) was established by the state to promote technological innovation and application of technology and to encourage the development of new products, innovations, and inventions or markets in Connecticut by providing financial and technical assistance. Through seven programs–Product Development Investments, Product Marketing Investments, Connecticut Seed Venture Limited Partnerships, Yankee Ingenuity Initiative Grants, and more—CII dispensed more than $21,000,000 in 1996 to companies, colleges, and universities.

Biotechnology is a chief target of the State's attention to its growing innovative industries. In an introduction to CII's 1996 annual report, Governor John Rowland notes that he had just received the Biotechnology Governor of the Year award from the Biotechnology Industry Organization, a consortium of 600 national companies. The State recently passed two pieces of significant legislation, one allowing biotech companies to receive exemptions on sales, use, and property taxes for machinery and equipment used in biotech research and development, and the other authorizing CII to develop a facilities credit enhancement program enabling biotech companies to procure laboratory space.

A count done by the CTC in March of 1996 revealed a total of 8593 technology firms based in Connecticut, employing more than 221,000 out of a total workforce of 1.4 million. Technology-based industries represent 9% of all companies doing business in the state and nearly 17% of all employees in the state. More than 26% of total payroll was attributable to technology-based companies.

The fastest-growing technology-based industries added more than 10,000 new jobs between 1990 and 1996. By far the most significant growth took place in the computers and software industry, where more than 8000 jobs were added while the Connecticut economy as a whole was declining by a total of about 71,000 jobs. Software employment grew by 20% in the 1990s, outpacing every major Connecticut industry sector, and strong

growth into the next century is forecast.

Another growth area is photonics. New England is currently home to more than 600 photonics companies, 134 of which are based in Connecticut. In 1997, the University of Connecticut Photonics Research Center estimates that the industry employs approximately 13,000, up 18.8% from two years earlier. From 1995 to 1997, the Connecticut photonics industry created 1600 jobs. Within this sector, materials (up 66%), imaging (up 42%), and lasers/light sources (up 33%) showed the highest growth rates.

The CTC reports that the 1997 legislative session was a reasonably good one for technology businesses in Connecticut. Reductions in corporation taxes and additional tax credits currently on the books were not rescinded, and the CTC's public policy agenda gained a strong foothold at the capitol, setting the stage for pro-technology legislation in the 1998 session.

Maine

In 1996, Maine's gross state product (GSP) was roughly $30.4 billion, up 1.5% from the year before. This represents about 7% of the total New England economy, which grew 2.6% from 1995-1996. But in an era of very moderate if positive growth, Maine's economy has grown more slowly than the New England economy in five of the last six years.

Maine differs from the other regional states in many ways, including the relatively small size of its technology-based business community. One thrust of state and business leaders' efforts is unique: its long coastline means that Maine is a marine state. The Department of Marine Resources is spearheading an effort to strengthen the marine research institutions in the state, as well as the industries that use marine resources. Along with stabilizing the number of jobs in traditional fisheries, and doubling those in cultivated fisheries, the department aims to create 1500 marine science and technology jobs over the next several years.

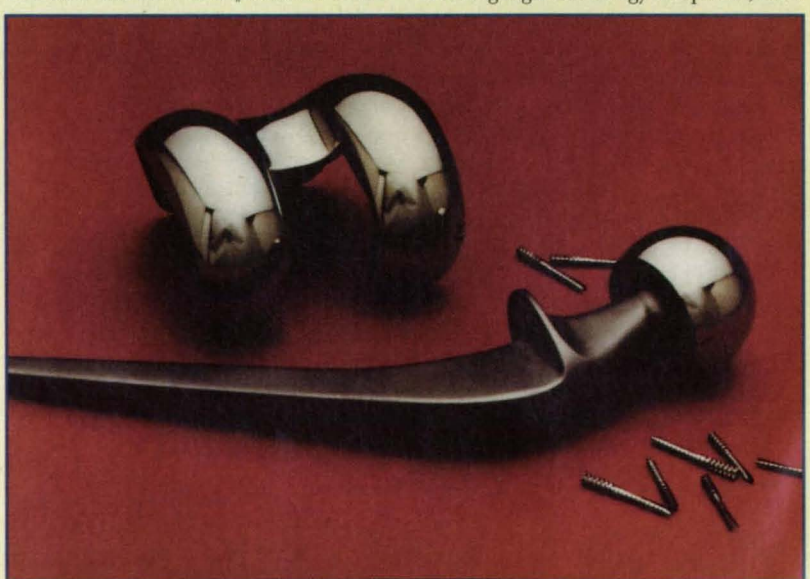
But Maine is looking at other sectors as well. The Maine Science and Technology Foundation is a state-chartered not-for-profit organization to encourage research and development, technology transfer, and the development of new commercial products and their fabrication in the state. Components of the Centers for Innovation Program include the Center for Innovation in Biomedical Technology (CIBT) and the Center for Technology Transfer, together designated as a satellite to NASA's Regional Technology Transfer Center. The latter helps the state's small-to-medium-sized metals and electronics firms adapt to changing technology. Numbering more than 450, these firms account for more than 30% of Maine's manufacturing earnings and manufacturing workforce. The Experimental Program to Stimulate Competitive Research (EPSCoR) is a Federal-state initiative to provide seed funding for the continued development of the state's research infrastructure.

From 1995 to 1996, the number of new businesses started in Maine went from 3982 to 4476, an increase of about 12%. For the same period, the number of new businesses started throughout New England did not increase. One area of rapid growth has been biotechnology. The number of biotech firms has increased to 48, and two firms that wish to relocate to Maine from Massachusetts are being recruited. Industry gross revenues for 1996 are estimated to have been $345 million, an increase of 30% over 1995, with the corresponding creation of nearly 600 new jobs. Gross profits in biotech approach 60%, translating into higher-paying jobs. The state has created a $5-million FAME Small Enterprise Growth Fund, and has given top priority to an early-stage venture capital fund capitalized at $20 million.

Massachusetts

Massachusetts, it is obvious, towers over its New England neighbors when it comes to the creation and fostering of high-tech industry. Price Waterhouse's "National Venture Capital Survey" for 1995-1996 shows that California and Massachusetts together accounted for 41% of all venture capital investment dollars and 45% of all deals. Behind only the behemoth California, the state of Massachusetts saw $1,547,000,000 invested in industry for the period, much of it in high-tech startup ventures. Between 1990 and 1996, initial public offerings of technology-based companies in Massachusetts numbered 141, again behind only California's voluminous 465, and well ahead of more populous states such as New York (99) and Texas (101). Likewise, in the number and amount of Small Business Innovation Research Phase I and II awards for the three years 1993-5, Massachusetts ranked second (1909 awards totalling $346,000,000) only to California, with almost three times as many awards as third-place Virginia.

Massachusetts's assets are well known. The state is endowed with a rich cluster of first-rate educational institutions and path-breaking high-technology companies, all of



The longuard® process was developed by SPIRE Corp. of Bedford, MA, to provide improved wear properties for orthopedic implants such as the knee prosthesis shown here. This SBIR-funded process is now used in more than 50,000 orthopedic implants every year.

which have been fertile breeding grounds for technological innovation and entrepreneurial energy. Twenty-seven percent of the Commonwealth's population is college-educated, the highest in the nation, and the state also ranks first in the per capita percentage of residents with advanced degrees in science and engineering.

But if the Commonwealth's assets are well known, so are its liabilities. The Department of Defense downsizing of the eighties and nineties hit the high-tech sector hard, and the recent period of economic expansion is just taking off. In the past Massachusetts's government had a reputation for being a swollen bureaucracy, and its legislators' zeal for state-funded program earned it the unfortunate sobriquet "Taxachusetts."

But recent years have seen a vigorous effort to change the Commonwealth's image, led by Governors Weld and Cellucci, and the Department of Economic Development. Among legislative measures have been a tripling of the investment tax credit; an increase in the R&D tax credit to as much as 15%, making it the highest in the nation; establishment of Mass Development's Emerging Technologies Fund to support job-creating facility construction; establishment of the Small Business Capital Access Fund to stimulate loans to small and medium-sized companies; and reform of the workers' compensation system.

Another recent initiative intended to advance the Commonwealth's competitive position by reducing business costs is the single sales factor. It eliminates the tax penalty businesses currently face when they create jobs or increase investment. Under the old law, companies were taxed under a formula that included in-state sales, in-state employment, and in-state property. The new formula taxes in-state sales only, benefitting Massachusetts manufacturers with most of their employment in state and the majority of their sales made to regional, national, and worldwide markets. The proposal could reduce the tax burden on industry by $100 million, and legislators expect it will help to keep large companies in the state.

Massachusetts is also plentifully supplied with industry associations that work for the leading advanced industries: the Mass. Biotechnology Council, the Mass. High Tech Council, the Mass. Software Council, the Mass. Telecommunications Council, the Center for Technology Commercialization, and many more. These groups act as permanent liaisons for industry to the Massachusetts Office of Business Development and other parts of state government.

New Hampshire

In the late 1980s the New Hampshire economy was riding high with defense-related and computer companies employing thousands of workers. But with cuts in defense spending and computer company downsizing, many middle-management jobs were eliminated. Still, the entrepreneurial spirit of these skilled, computer-literate and business-savvy people has generated many small high-tech and software-related businesses in the state. Some of these, such as Cabletron and Poly Vac, have literally gone from garage to major corporation.

A pivotal factor encouraging business location in New Hampshire is its positive tax structure. The fact that New Hampshire's government did not raise taxes or increase regulations during the early 1990s benefitted the small- and medium-sized companies that require stability and predictability. Incentives for business include no sales or personal income tax, no inventory tax, no property tax on machinery or equipment, and investment tax credits for business. The Office of Business and Industrial Development (OBID) has worked to assist companies during and after the recession of the early 1990s.

State authorities have focused on existing small-and medium-sized businesses, and steady incremental growth of these has been the driving force in turning the economy around. The strategy has enabled support of key business concerns such as the development of technology, workforce strengthening, and identification of new market opportunities for New Hampshire products.

A recent study by the American Electronics Association stated that New Hampshire's concentration of high-tech workers per thousand population is the highest in the nation. It is this that has helped companies such as Oracle and Cabletron to find the quality workforce needed to grow.

Rhode Island

Rhode Island has many technological assets, including research universities–Brown and University of Rhode Island, research institutes–most notably the Naval Undersea Warfare Center, and a number of technologically-based companies both in traditional manufacturing and high-tech sectors such as electronics, biotech, and software. Overall, its university-funded R&D is 33% higher than the national average, and it ranks ninth in science and engineering students. But a recent report from the state's Economic Policy Council asserts that Rhode Island has not fully capitalized on its assets. Compared to others in the region, Rhode Island is not home to large well capitalized technology-intensive firms that are most likely to fund R&D. Federal R&D funding is lower than the national average. In 1983, Massachusetts industry performed approximately twice as much R&D per worker as Rhode Island industry. Ten years later, this had increased to six times more.

In spite of this, a number of technologically based companies are situated in Rhode Island, including Astro-Med, Cherry Semiconductor, and Philips Industries. And the state is taking a larger role in building connections between research institutions and businesses. It has funded a Partnership for Technology Development whose mission is to encourage the state's businesses to work more closely with its universities, colleges, and hospitals on science, technology, research and development, and innovation. The Partnership's Applied Research Grant Program had funded nine projects totaling $3,328,000 through 1993. In 1996, the Legislature passed a Research Centers of Excellence Program.

Recent legislation raises the tax credit for increases in research and development expenses from 5% to 22.5%, making it the highest in the nation.

Vermont

Vermont has moved aggressively to improve its standing in the realm of high-technology business. In 1992 a volunteer group of citizens formed the Vermont

Technology Council, for the purpose of bringing together college and university research resources, the entrepreneurial capacity of the business sector, and the support and collaboration of state government in new ways for the benefit of the state economy. The result was Governor Howard Dean's Executive Order of November 1993 decreeing a Science and Technology Plan for the state, to be written by a Science and Technology Committee. A year later the Plan was presented to the Governor and adopted.

The Committee isolated four areas it felt the state should focus attention on: the food processing industry, the environmental science industry, biotechnology, and advanced materials technologies. It also identified several infrastructure initiatives key to enhancing the science and technology initiatives: EPSCoR (Experimental Program to Stimulate Competitive Research), a Federal-state partnership to advance competitiveness; the Manufacturing Extension Center, to bring science and technology to the state's manufacturers as efficiently as possible; Telecommunications, a push to advance the state of the art of this significant area; stimulating use of the Small Business Innovation Research Program to gain start-up money for research and commercialization; and a drive to transfer technology from the state's academic research institutions to private and public enterprises.

To date, the total commitment of funds to the Vermont Technology Council from the National Science Foundation, NIST, the state, and Vermont industry amounts to more than $10,000,000.

An example of Vermont's progress in its efforts is the recent announcement that Husky Injection Molding Systems, one of the world's leading innovators in the field, will move forward with construction of a campus-style facility in Milton, VT. Husky expects to employ 240 people for the $90-million first phase of the manufacturing campus, which is scheduled to be completed in June 1998. The ten-year plan for the facility calls for 700,000 square feet of manufacturing facilities, employing as many as 1000 people. According to Husky's president, Robert Schad, the hot runner operation planned for the site will be a showcase of modern manufacturing.

NEW ENGLAND TECHNOLOGY LEADERS ON DISPLAY AT TECHNOLOGY 2007

Technology 2007 will afford attendees a unique opportunity to view the region's most innovative new products and inventions. Among the regional companies exhibiting at Boston's Hynes Convention Center, Sept. 22-24, are the following:

(Red type indicates company advertises in this showcase.)

NEW ENGLAND PAVILION

3M Specialty Optical Fibers
West Haven, CT
Leading manufacturer of polarization-maintaining and specialty single-mode fibers and assemblies, large-core multimode fibers and assemblies, including hard-clad silica, and custom fiber Bragg gratings. (See page 8N.)

ADINA R&D Inc.
Watertown, MA
Featuring ADINA, a finite element system for stress analysis of structures and fluid flows (CFD), with heat transfer and seamless connections to CAD programs such as ProENGINEER, I-DEAS, AutoCAD, and PATRAN.

Boston U. Photonics Center
Boston, MA
State-of-the-art photonics lab.

IMAGEX Technologies, Inc.
Framingham, MA
IMAGEX is developing a unit for security of documents that "erases" the image from photocopied/laser-printed documents.

Inventors' Digest
Boston, MA
America's No. 1 inventors' magazine is information-packed, showing how to go from idea to viable product. Distribution: 15,000.

JENTEK Sensors, Inc.
Watertown, MA
JENTEK provides thin, conformable, inductive and capacitive sensors for measuring proximity, coating thickness, and physical properties to support manufacturing quality control.

Macsyma, Inc.
Arlington, MA
Macsyma® combines symbolic, numerical, and graphical mathematics in scientific notebooks with on-line help. PDEase® FEA software's animated graphics and automatic grid generation solve static, dynamic, and eigenvalue problems. (See page 13N.)

Microcal
Northampton, MA
Microcal's new Origin™ 5.0, technical graphics and data analysis software for Windows 95™ and NT®, is fast, flexible, and easy to use. (See page 14N.)

Precision Optics Corp.
Gardner, MA
POC provides thin films in cleanroom facilities. Specialties include low-defect, low-temperature, narrowboard press and highly durable coatings. Also optical design and development.

Smart Control, Div. of Sandblast Services, Inc.
Oakland, ME
Innovative international firm engaged in R&D, prototyping, and testing new products for commercialization in metalworking, ergonomics, mechanical, fluid power, transportation, consumer, et al.

Winchester BioConnections
Winchester, MA
Helping you tailor the messages that drive faster market acceptance and adoption of your technology, from obtaining startup monies through product launch to market dominance.

CONVENTION FLOOR

Belt Technologies/Booth 120
Agawam, MA
The company manufactures metal belts, drive tapes, and pulleys used for indexing, conveying, power transmission, and timing. (See page 26N.)

Concepts ETI/Booth 817
White River Junction, VT
Fully integrated engineering design software, turbomachinery design and development services, testing, troubleshooting and design audit services.

Fred V. Fowler, Inc./Booth 1000
Newton, MA
Manufacturer of positional, capacitive, and inclination sensors, RF identification tags, and calibration and quality-control devices.

Geophysics Directorate/Booth 101
Hanscom Air Force Base, MA
Phillips Labs' Geophysics Directorate's cutting-edge air and space technology enables the warfighter to operate successfully in the challenging environment between Earth and Sun.

BF Goodrich Aerospace/Booth 221
Vergennese, VT
The company provides fluid measurement/management, health monitoring, proximity sensing, system integration, and development using simulation and emulation.

Hardric Laboratories/Booth 916
Waltham, MA
A maker of metal mirrors for laser systems, the company offers a new product for carbon dioxide and Nd:YAG lasers: HardZap high-power, low-scatter beryllium mirrors.

Inframetrics, Inc./Booth 1010
North Billerica, MA
The company will display the ThermaCAM SC1000 focal plane infrared camera, which offers full-screen temperature measurement and unmatched accuracy. (See page 20N.)

Invention Machine/Booth 210
Boston, MA
Invention Machine Lab, Tech-Optimizer, and Im-Phenomena software packages help engineers in the conceptual stage of design of a product or process. (See page 24N.)

Marc Analysis Research, Inc./Booth 406
East Berlin, CT
This nonlinear finite-element analysis software maker is a leader in the simulation of contact in manufacturing processes and assembly.

Microway Inc./Booth 1001
Kingston, MA
If your application is a big-time number cruncher or a DSP application that needs more than 32 bits of precision, you should have a Microway "Screamer" workstation. (See page 18N.)

MIT Sloan School of Management/Booth 1002
Cambridge, MA
The first master's degree program in the world to focus on the management of technology and innovation. Upon completion of the program, participants earn the degree Master of Science in the Management of Technology.

Nuclear Metals, Inc./Booth 316
Concord, MA
This technology/materials development company has invented an investment castable beryllium aluminum alloy, Beralcast®, that is being used in satellites.

Recognition Technology/Booth 121
Framingham, MA
Providers of interferometric computers and optics modules for electronic holography, speckle correlation, shearography, and projected fringe moire for NDT, vibration, and deformation analysis.

Romer/Booth 707
Agawam, MA
Manufactures and distributes the Romer portable CMM, a unique six-axis articulated arm CMM.

Sensable Technologies, Inc./Booth 213
Cambridge, MA
Makers of the Phantom haptic interface, a force-feedback device that allows users to touch and manipulate 3D virtual objects, and Ghost software toolkits enabling applications to incorporate 3D touch.

Team Technologies/Booth 312
Newton Upper Falls, MA
The SCAEP air sampler/concentrator collects and concentrates contaminants, such as pollutants and small quantities of explosives, in large volumes of air into samples at high capture efficiencies.

Techni Products/Booth 314
East Longmeadow, MA
The company is a precision machine-parts manufacturer with a modern manufacturing facility of 30,000 sq. ft.

Thoughtventions Unlimited/Booth 100
Glastonbury, CT
The company offers a high-temperature transparent furnace.

Toroidal Power Systems/Booth 321
Billerica, MA
The company will exhibit a transmission that employs a 3D kinematic toroidal path to convey torque and power to the output shaft.

Walker Magnetics/Booth 423
Worcester, MA
Magnetic instrumentation and industrial magnetic products for workholding, lifting, material handling, and recycling.

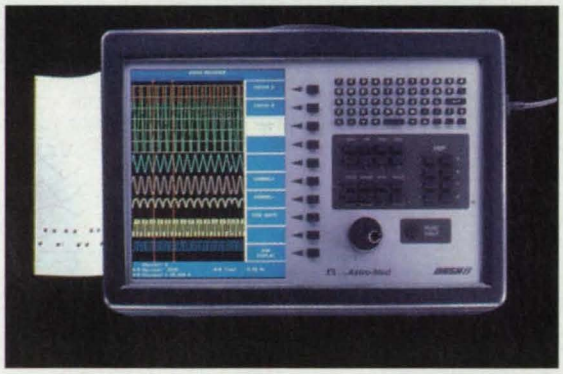
Astro-Med, Inc.

Astro-Med, Inc.

Astro-Med, Inc. is a leading supplier of specialty printer solutions to customers around the world. Astro-Med customers include leading aircraft manufacturers such as Boeing, Lockheed, McDonnell Douglas, and British Aerospace; automotive product manufacturers such as Chrysler, Ford, General Motors, Mercedes Benz, and Renault; telecommunications giants such as AT&T, NYNEX, and MCI; electrical utility companies including Northeast Utilities, Hydro Quebec, and Florida Power and Light; steel companies including USX, Posco, and Bethlehem; aluminum manufacturers such as Alcoa Reynolds; and paper manufacturers including International Paper, Kimberly-Clark, and Mead.

At Eglin Air Force Base in Florida, banks of Astro-Med MT95K2s record important telemetry data.

Astro-Med customers include Fortune 500 companies as well as small operations. They are located around the world, wherever there exists a problem which can be solved by an Astro-Med specialty printer.



New portable 8-channel recorder.

Astro-Med specialty printers are total systems that display, monitor, analyze, and print data for aerospace, industrial, and medical applications. The machines, computer electronics, software, and consumables all are developed and manufactured by the company.

Examples of Astro-Med products include the MT95K2, which has become the world standard in chart recorders, especially in telemetry applications. Because of its power and versatility, the 32-channel K2 can perform a variety of tasks that previously required a battery of instruments. Other recorders from Astro-Med include the "Dash" line of portable units, which range from 2 to 30 channels. The recently introduced Dash 8 is an 8-channel recorder that features a 10.4-inch color LCD monitor, a 2-Gigabyte internal hard drive, and a 100-Megabyte removable Zip drive for data transfer and archiving.

Other Astro-Med products include portable paperless data acquisition systems. The AstroDAQ is a complete, ready-to-use system that can record up to 30 channels. The recently introduced AstroDAQ 2 is a very compact and lightweight version, especially suitable for portable field applications.

Astro-Med has also extended its technology to other specialty printers. The Tough Writer 2, a reliable, compact, ruggedized, high-speed PostScript page printer, is designed to withstand the rigor of military, airborne, shipboard, and industrial applications.

Astro-Med is a growth-oriented company which believes in vigorous new product development, in high-quality products, and in total customer satisfaction. Astro-Med's executive offices, R&D, and manufacturing facilities are located in West Warwick, RI and Braintree, MA. Astro-Med maintains sales and service offices throughout the U.S. and in London, Frankfurt, Paris, Milan, and Montreal. Astro-Med products are sold around the world by a combination of direct sales and service centers, and dealers, distributors, and representatives.

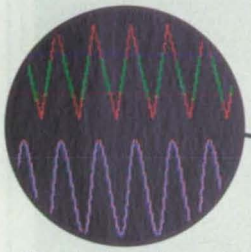
Astro-Med, Inc.
Astro-Med Industrial Park
West Warwick, RI 02893
Tel: 800-394-4039
Fax: 401-822-2430
e-mail: astro-med@astro-med.com
WWW: www.astro-med.com

Circle No. 621

The All New Dash 8 Field Recorder From Astro-Med...

Big COLOR Monitor! Big Memory!

Small Package!



When signal exceeds pre-set limits, waveform automatically changes color.

- **10.4 Inch Active Color LCD Monitor – Color Code Each Waveform for Quick Analysis**
- **2 GB Internal Hard Drive & 100 MB Zip® Drive**
- **8 Channels – 2 kHz Response**
- **Isolated Input Range – 50 mV to 500 V FS**
- **DSP for Filtering, RMS, Integration, and Derivative**
- **Handy Z-Fold Chart**
- **Rugged, Compact, Portable – Less than 20 lbs**

Look at data in real time on the color monitor and chart or record data to the big internal hard drive for playback and review later on the big, bright color monitor. Or, transfer data to the built-in removable Zip drive and use your computer for further analysis or archiving. The *all new* Dash 8 – truly a remarkable recorder and data acquisition instrument you can take anywhere.

Call, E-mail, Fax, or write to us today for all the details.

Astro-Med, Inc.

Astro-Med Industrial Park, West Warwick, Rhode Island 02893
Telephone: (401) 828-4000 • Toll Free: 800-343-4039 • Fax: (401) 822-2430
In Canada Telephone Toll Free: 1-800-565-2216
E-mail: astro-med@astro-med.com • **Web Site:** www.astro-med.com

Sales and Service Centers throughout the U.S., Canada and Europe.
Dealers located throughout the world • Astro-Med is System Certified to ISO 9001

For More Information Circle No. 540

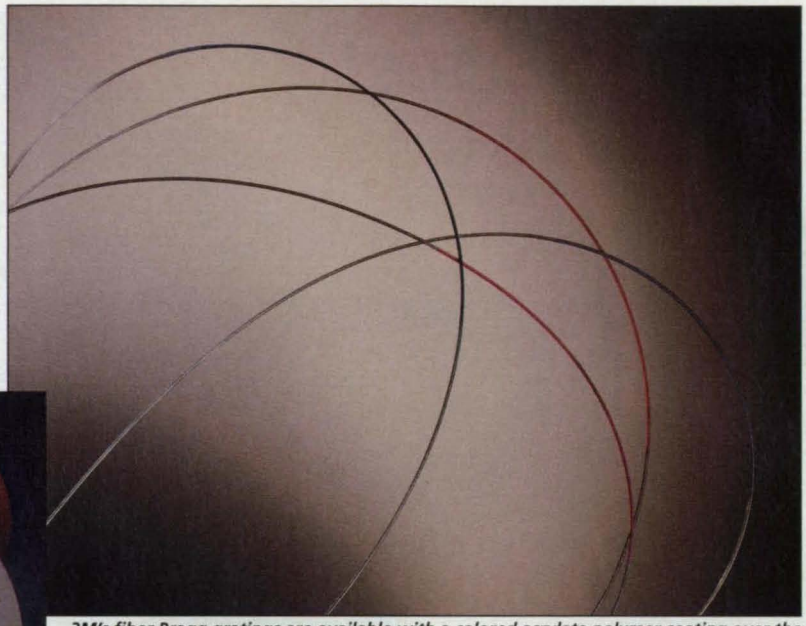
3M Specialty Optical Fibers
3M Bragg Grating Technologies

Optical Fibers and Bragg Gratings Backed By the Resources of 3M

3M Specialty Optical Fibers/Bragg Grating Technologies is a vertically integrated manufacturer providing world-class specialty optical fibers and gratings. Our capabilities in fiber preforms, coating, waveguide design, and terminations allow us to meet virtually any need. 3M's fiber Bragg gratings, specialty single-mode fibers, and large-core multi-mode fibers represent the most complete line of specialty optical fiber products in the world. And, they're backed by the technological, engineering, and manufacturing resources of 3M.

We maintain active, ongoing fiber optics research and development programs, and we take advantage of the vast resources and technological information within 3M. Our facilities in West Haven and Bloomfield, Connecticut house state-of-the-art production equipment, and we provide to you the very latest technology 3M has to offer.

3M Specialty
Optical Fibers
420 Frontage Road
West Haven, CT 06516
Tel: 203-934-7961
Fax: 203-932-3883



3M's fiber Bragg gratings are available with a colored acrylate polymer coating over the reclad region.

Fiber Bragg Gratings

As a fully licensed Bragg grating supplier, 3M focuses on the design, development, and manufacture of fiber gratings for the telecommunications, sensor, and research markets. Through the integration of 3M's fiber and grating resources, you now have commercial availability of gratings written in fiber designed specifically for gratings fabrication, along with the research capabilities, volume manufacturing strength and product quality that 3M is famous for.

Specialty Single-Mode Fibers

3M's leadership in polarization-control fiber technology is based on our "shaped-cladding" fiber. Our investment in this technology has resulted in fibers of unparalleled consistency and high tolerance. Products such as our single-polarization fiber, polarization-maintaining fibers from 500 to 1550nm, and assemblies are used for aerospace, military, and advanced communications applications. In addition to polarization-controlling fibers, 3M manufactures high NA fibers and fibers operating in the visible as well as other non-telecommunications wavelengths.

Large-Core Multi-Mode Fiber

This broad line of step-index PowerCore fibers and assemblies are designed and manufactured to meet a wide variety of transmission and environmental requirements found in the medical, industrial, spectroscopy, military, and data communications markets. Products include the popular TECS™ hard-clad fiber and the high-power SMA 905 assemblies.

Emphasis on Technical Support

3M's full-service customer support helps you with everything from application planning to system start-up. Our engineers will work with you to determine which fiber or fiber grating is right for your application. Or, we'll custom design a fiber or grating to provide the best solution for your application.

3M has extensive experience in fiber optics; a dedication to research and development; and a commitment to work closely with our customers from start to finish. They're all good reasons to put 3M to work for you.

Circle No. 618

From high tech... to high finance... to high in the sky

3M™ Specialty Single-Mode Fibers, Power-Core Fibers and Fiber Bragg Gratings ensure there's the right fiber for your application

3M Specialty Optical Fibers offers the most complete line of fibers available in the world today.

Whether you're checking the performance of fuel injectors from inside an engine, performing delicate, minimally invasive laser surgery, building the most advanced commercial aircraft in the air or creating sophisticated network systems, you can be sure that the fiber you need will be designed and manufactured to exactly meet your requirements.

3M Specialty Optical Fibers are the only fibers and gratings backed by the technological, engineering and manufacturing resources of 3M. Since we're vertically integrated, we control the process from preform to termination. Plus, by combining our expertise in polymer coatings with our strengths in optical fiber waveguide design, we produce truly high-performance optical fiber solutions.

And, because of our strong commitment to customer satisfaction, you get support from application planning through system operation, help with custom fiber designs for your tough applications, and ready availability and on-time deliveries.

Call us today. Get the fiber that's *exactly* right for your application, plus the support of 3M. 3M Specialty Optical Fibers, 420 Frontage Road, West Haven, CT 06516-4190. Telephone (203) 934-7961 or fax (203) 932-3883.

3M *Innovation*

Alacron

Alacron is a leader in the design, development, and manufacture of high-performance coprocessor subsystems for demanding real-world imaging and DSP applications. Alacron offers a comprehensive line of coprocessors for PCI, CompactPCI, VME, and ISA bus computers, state-of-the-art microprocessors.

Alacron's coprocessors are supported by an extensive array of interchangeable I/O modules, including framegrabbers, hi-res graphics interfaces, SCSI, VSB high-performance digital I/O, and PMC modules. Alacron's solutions include extensive libraries of micro-coded image and signal processing algorithms. Alacron's customers include a wide range of OEMs, government agencies, research institutions, and universities.

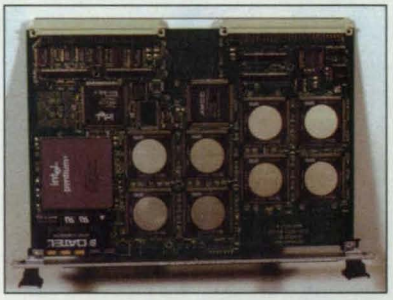
Markets served include Machine Vision, Optical Character Recognition, Document Processing, Real-Time Inspection, Laser Radar, Real-Time Signal Processing, Digital Audio Processing, Spectral Analysis, Vibration and Noise Analysis, Robotic and Servo Control, Pattern Recognition, ADPCM Coding/Decoding, Video Data Compression, Medical Imaging, Radar Sonar, Multimedia, Numerical/Array Processing, Speech Processing/Recognition, Communications, CAD/CAM, Signal Intelligence, and Seismology.

Alacron's application engineering team assists OEMs and end users to optimize the design of the products and applications, making full use of Alacron's high-performance coprocessing and I/O systems.

Products

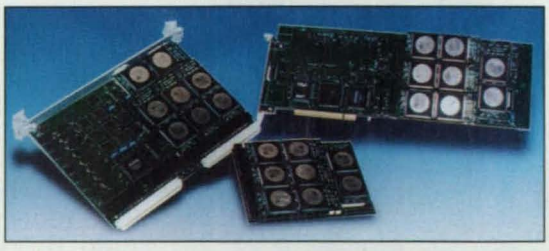
- **Computing Systems:** Integer and Floating Point systems based on SHARC and i860 processors.

Alacron's FT-DOMINATOR series of scaleable high-performance computing subsystems, incorporating an array of up to 8 ADI-2106x SHARC microprocessors and an Intel Pentium controller, are designed for distributed, compute-intensive applications. The FT-Dominator delivers very high floating point performance for the most demanding real-time DSP and imaging applications. A single FT-Dominator provides nearly one GigaFLOP performance in a desktop environment. Interconnected using their PMC-compatible FastTrack™ II dataports, Alacron's FT-Dominators serve as nodes on Myrinet System or Local Area Networks.



Alacron's FT-Dominators deliver high levels of performance for imaging, graphics, simulation, DSP, document processing, and pattern recognition applications. The FT-Dominator series is ideal for adding scaleable capability to existing systems and for developing new systems from the ground up.

Alacron's FT-2106x processor boards also incorporate a scaleable array of up to 8 Analog Devices' ADSP2106x SHARC processors. Alacron's FT-2106x systems support a wide variety of interchangeable I/O modules and framegrabbers.



- **Gigabit LAN Interconnects:** High-Performance LAN Clusters using VME and PMC format interfaces.

Alacron provides high-speed LAN connections through a combination of PMC and VME interfaces. These boards can be used to build Gigabit-per-second System Area Networks (SANs), allowing several computers to work as a system cluster. Individual computers containing the SAN/PMC interface can be linked using the VME SAN switch module.

- **Framegrabbers:** Analog and digital framegrabbers, available as bus modules, integrated processor/framegrabber modules, and FastTrack daughter cards.

Using a combination of PCI bus modules, FastTrack daughter cards, and integrated camera interfaces, Alacron provides a wide range of options for image acquisition and processing. You can begin with image acquisition and add processing capability as the requirements demand, all from one vendor—Alacron. Alacron's FastTrack Architecture provides scaleable computing/acquisition that can be tailored to your project needs.

- **High-Performance I/O Daughter Card Modules:** Serial, parallel, SCSI, VISIONbus, DT-Connect, and high-performance video subsystems. PMC module support.

Alacron's interchangeable I/O modules support a wide variety of I/O requirements. Alacron's I/O modules are daughter cards that mate with the 160 MB/sec FastTrack expansion connectors on Alacron's FT-2106x, FT-200, and AL-860 processor boards. Each processor board has two FastTrack connectors, and daughter cards can be stacked, allowing a maximum of six daughter cards on a processor board. Additionally, Alacron's FT-Dominator supports all standard PMC cards.

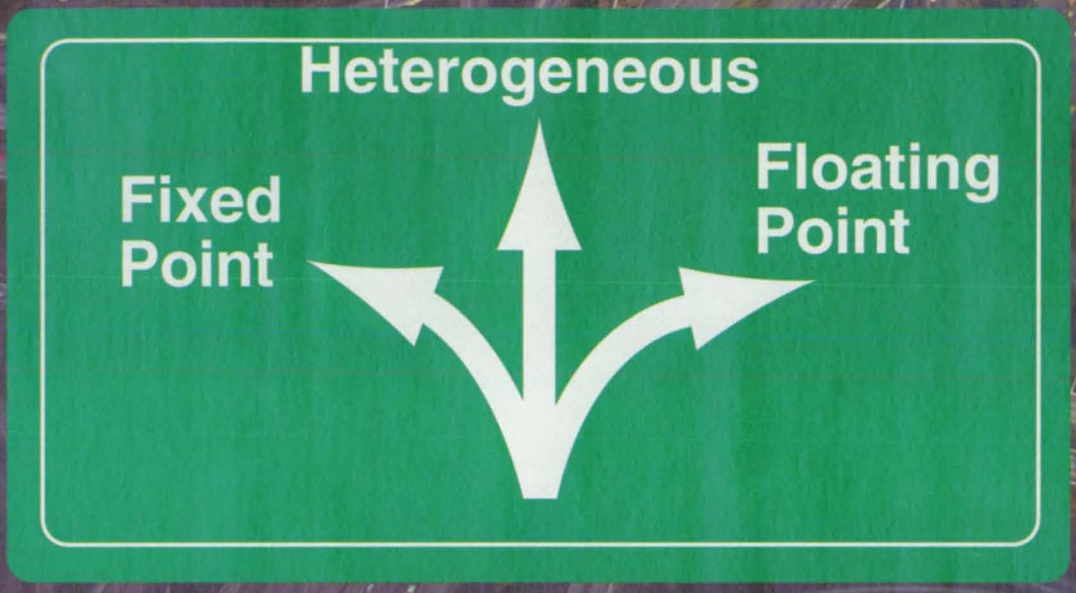
- **Software Development/Execution Support:** Tools and libraries needed to develop solutions for high-performance applications.

Alacron's combination of development tools, operating systems, I/O support and applications libraries provide the software needed to go from concept to working high-performance systems. Alacron provides a wide range of support tools to get your applications up and running.

Alacron
71 Spitbrook Rd., Ste. 204
Nashua, NH 03060
Tel: 603-891-2750
Fax: 603-891-2745

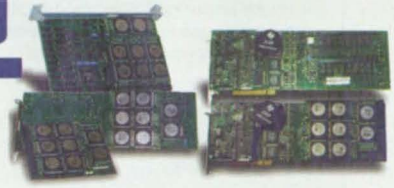
Circle No. 625

Whatever Direction Your Computing Needs Take You ...



They All Lead To

ALACRON



High Performance Integer Calculations	
• 3 x 3 convolution	6.6 msec
• Dilation / Erosion	1.2 msec
• Add, subtract, threshold	2.4 msec
• Median filter	11 msec
• Sobel / Robert's filter	6.0 msec
• Histogram	3.3 msec

High Performance Floating Point Calculations	
8 SHARC 1DCFFT (1K)	0.072 msec
8 SHARC 2DCFFT (1K x 1K)	.138 msec
8 SHARC CONV3 (512 x 512)	9 msec

Alacron provides the optimal processing power for all your computing needs. Alacron's FT-C80 supplies 2 Giga Fixed Point OPs, while the FT-SHARC supplies up to 3 Giga Floating Point OPs per slot!!

The FT-SHARC and FT-C80 support Alacron's family of digital and analog framegrabbers, and Alacron's high resolution video output modules.

ALACRON
71 Spitbrook Road, Nashua, NH 03060
TEL: (603) 891-2750
FAX: (603) 891-2745
Web: http://www.alacron.com
EMAIL: sales@alacron.com

UNITRODE

Unitrode Corporation

The Linear IC Company Everyone Follows

Unitrode Corporation is a world-renowned leader in the design and manufacture of high-performance, value-added analog/linear and mixed-signal ICs. The Company's reputation and success as an innovator has achieved significant technological breakthroughs in all areas of power management, motion control, and high-speed data communications. Unitrode's expertise includes the pioneering of current mode pulse width modulators, topologies, and intelligent motor drivers.

A source ringer controller, the UCC3750 provides complete control and a drive solution for telephone ring circuits.

History

Founded in 1960 in Waltham, MA, Unitrode has grown by internal development and acquisition. Publicly traded since 1966, the Company has been listed with NYSE since 1972 and trades under the symbol UTR. After a successful divestiture program in which several non-strategic businesses were sold, Unitrode today focuses on its highly successful analog/linear and mixed signal integrated business.

Product Portfolio

Developing high-quality products for commercial, industrial, and mil/aero applications, Unitrode's product portfolio includes off-line power management devices, DC/DC portable management, protection/supervisory circuits, portable power management, motion motor controls, and high-speed interface circuits. The Company also offers an assortment of special function ICs including fiber-to-curb ringers, C.A.N. transceivers, IrDA transceivers, cellular power management products, and pager/PDA power controllers.

Unitrode Corporation
7 Continental Blvd.
Merrimack, NH 03054
Tel: 603-429-8725
Fax: 603-429-8963
WWW:
http://www.unitrode.com

Process Capabilities

Unitrode uses several processes to ensure quality and innovation. These include a bipolar process which is constantly updated to incorporate leading-edge process options, a BiCMOS process, and the addition of the new BCDMOS process.

Service

Supporting worldwide customer needs with a commitment to quality, reliability, and innovation, Unitrode has design centers in New Hampshire, California, and North Carolina. The Company features extensive test, assembly subcontractor coordination, and customer service facilities in Singapore, and houses a network of manufacturers' representatives and distributors.

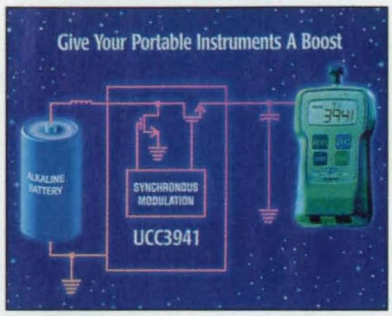
Latest News

Unitrode's widely-acclaimed Switching Power Supply Design Seminars are scheduled to begin in early fall. Hosted worldwide, these events are touted as the best technical seminars in the industry. The seminars will convene through 1997-1998 and will emphasize the practical aspects of switching power supply design at an intermediate technical level.

Unitrode is a key participant in the 1997 Pioneer Technology Exposition/ classroom-style training sessions being held in late summer/early fall in nine national cities.

Latest Technologies

Unitrode has several industry-first products which have been released this year. Such announcements include the Company's simple-to-use, cost-effective answer for developing high-voltage telephone ring signals. The UCC3750 is a source ringer controller that provides complete control and drive solutions for telephone ring generator circuits.



Low input voltage gives your portable instruments a boost.

The UCC3941 is a 1V synchronous boost converter optimized to operate from a single or dual cell battery. It is ideal for applications such as pagers and PDAs.

Announcing the new high-efficiency, high-power-factor preregulator intended to control a boost converter power stage, Unitrode has competitively priced the UCC3858 with other mid-level controllers. Well-suited for the international market, the UCC3858 incorporates such features as PWM foldback for higher efficiency at lighter loads - currently not available in other PWM controllers.

Technology's future provides longer distance, more devices, and greater speed with the low-voltage differential multimode terminator.

Circle No. 620

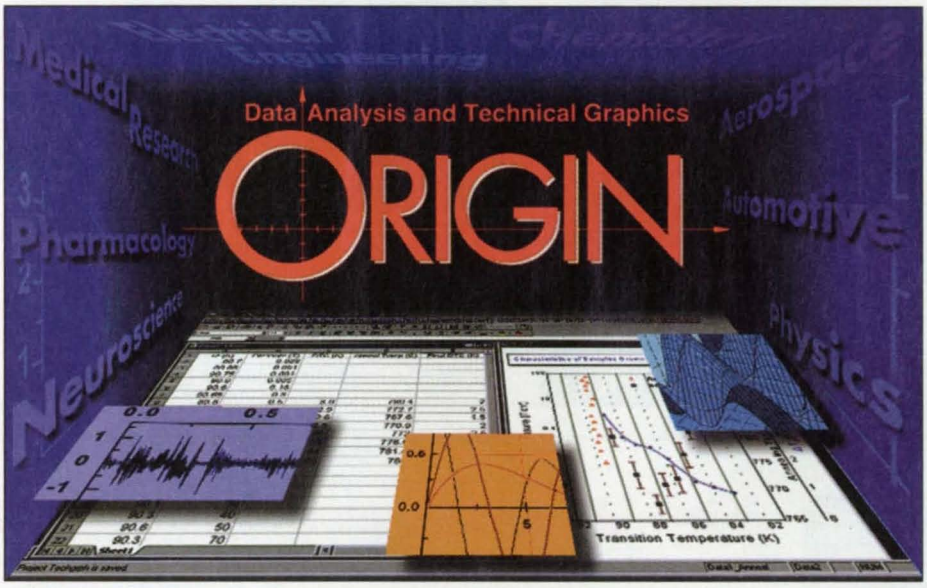
Microcal

Microcal™ Software, Inc.

Ease of Pharmacokinetics Analysis Improved With New Plotting and Analysis Software

by Eldon Nyhart, Senior Scientist, Eli Lilly & Co., Indianapolis, IN

In the past, Lilly researchers primarily used a Windows-based spreadsheet or other software to fit log-linear curves to drug concentration data. The researcher imported each of the data sets into the spreadsheet or program and took the natural log of one of the two columns, representing plasma level data. After transforming the data to a log scale, the researcher then used the linear curve-fitting function contained with the spreadsheet to determine the value of the slope and intercept. One problem with this approach was the amount of time that it took to manually handle large data sets. Another disadvantage was that the researcher was presented with the answer to the problem without being easily able to interactively participate in its solution. In some cases, a measurement error will lead to one or two points being widely scattered from the trend line. With the spreadsheet, these points have weighting equal to the valid data and often skewed the slope and intercept. The researcher could graph the data and identify outlyers, but then he or she would have to manually locate and eliminate the suspect data points and repeat the analysis process. In an effort to streamline this process, Lilly purchased Origin Version 4.0, a Windows-based technical graphics and data analysis software package from Microcal Software, Inc., Northampton, MA. This package greatly streamlines the process of fitting log-linear or other more complex curves to laboratory data. To fit the log-linear curve, the user simply opens the file containing the data in a graphic window and selects from the menu: Analysis: Fit Exponential Decay: First Order. After a short period of time, a smooth theoretical curve appears with parameter values displayed on the graph. Besides being faster, this approach also makes it possible to achieve more reliable results. The researcher sees the data on the screen and obtains a visual understanding of how closely the available data fits the curve. A pair of 95% confidence and prediction intervals appear superimposed on the data set, along with the calculated curve. The researcher can select a range of data by graphically selecting a portion of the data plot. Outlying points can be removed simply by clicking on them with a mouse. In either case, the curve and confidence and prediction intervals are instantly recalculated, making it possible for the researcher to interactively evaluate and improve the results. Also, different data weighting schemes are available during the fitting process.



Microcal Software, Inc.
One Roundhouse Plaza
Northampton, MA 01060
Tel: 800-969-7720 or
413-586-2013
Fax: 413-585-0126
e-mail: info@microcal.com
WWW:
http://www.microcal.com

Microcal™ Software, Inc. Presents ...

Microcal™ Software, Inc. is pleased to announce its latest release of Origin™ version 5.0. First released in 1991, Origin was the first software of its kind in the Windows environment.

Today, Origin continues that pioneering spirit by providing its users with unsurpassed flexibility, ease of use, and speed in its software. New features in Origin version 5.0 include:

- The ability to open and use Excel™ workbooks inside Origin
- Drag and drop editing in Excel
- Row size only limited to your machine's memory
- Import capabilities including KaliedaGraph®, Mathematica®, SigmaPlot™, Sound, DIF, and many more!
- OLE 2.0 compatible for easy report generation. Use PowerPoint® and CorelDraw™ for creating slides and reports.

Call 800-969-7720 for more information, or download our demo at www.microcal.com

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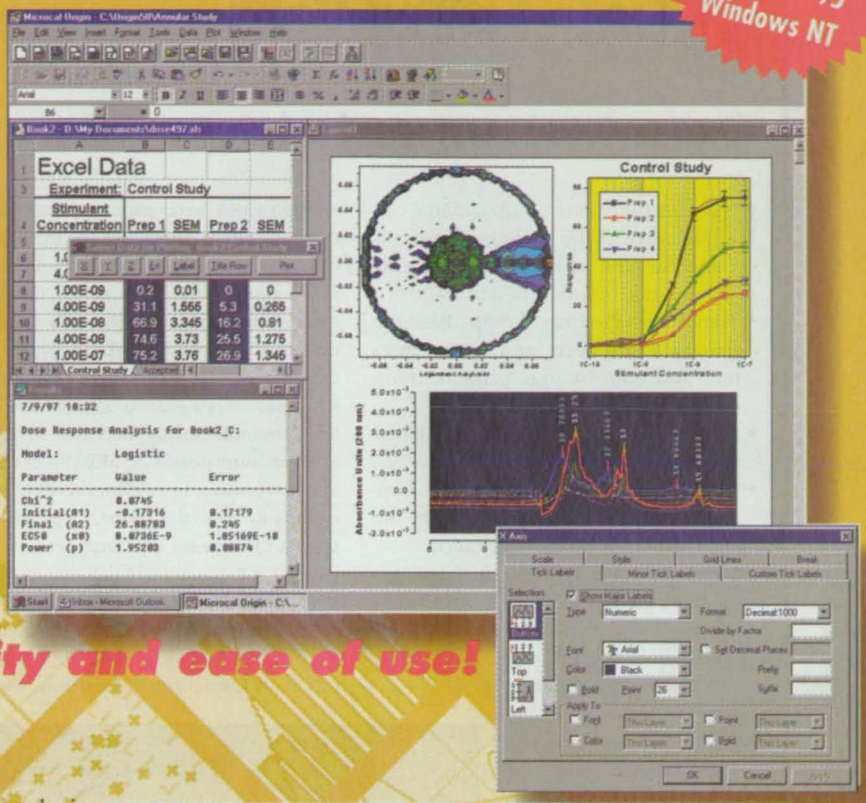
Circle No. 617

ORIGIN™ 5.0 For Windows™

NEW! 32-bit version Windows 95 Windows NT

Data Analysis and Technical Graphics

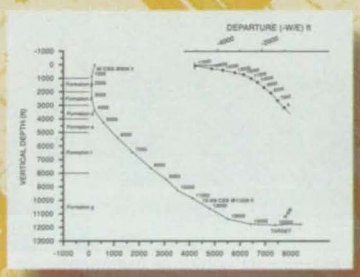
- Open Excel Workbooks
- Drag and Drop Plotting from Excel
- OLE 2 Server
- Notes Windows
- Shortcut Menus

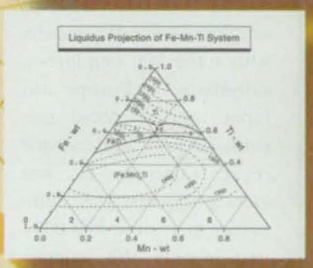


A new standard for reliability, functionality and ease of use!

Open and use Excel Workbooks inside Origin!

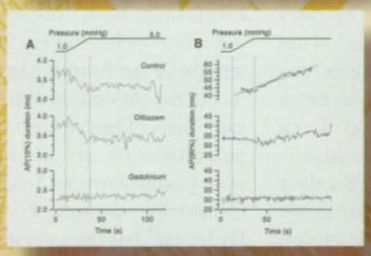
Use Origin's data analysis capabilities to perform analysis directly on your Excel™ data, and Origin's graphing power to create graphs right from your Excel worksheets. You can even drag and drop data from Excel to instantly create an Origin graph. Excel workbooks can be saved as part of the Origin project or as a link so that if you alter the workbook data outside of Origin, the Origin graphs are automatically updated when the project is re-opened.

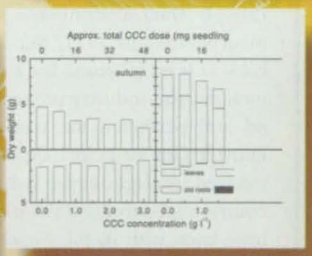




Tabbed Dialog Boxes Make Modifying Graphs Easy

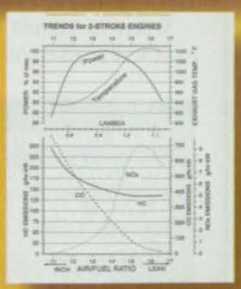
Double-click on any axis of the graph, and Origin opens the multi-tabbed Axis dialog box. Intuitive icons simplify axis selection. Specify different tick styles, create axis breaks, or choose the line type or the color of the grid lines — all in a single clutter-free dialog box.





OLE 2 Makes Presentations Even Easier

Create presentation-quality graphics for colleagues, journals or conferences by embedding your custom graphs in PowerPoint®, CorelDraw™ or any other presentation software. Origin 5.0 is an OLE 2 server, so you can edit your embedded graph using Origin's tools or update your linked graph automatically.



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DATA INSTRUMENTS

Data Instruments Inc.

Data Instruments is a multinational corporation with five major business units centered around such core areas as electronic sensors, transducers, and controls.

- Transducer Products Group: Position-sensing transducers and potentiometers, and stainless steel pressure transducers
- Advanced Silicon Group: Silicon-based micromachined pressure sensors
- Critical Fluids Group: Pressure measurement products for high-purity fluids used in electronics fabrication
- Detector™ safety light curtains for machine guarding
- Wintriss® Controls Group: Press automation, die protection, and safety controls for metal stamping.

Historical Background

Data Instruments is an employee-owned company with some 500 employees, subsidiaries in Europe and Japan, and a global network of sales and service representatives. It was among the first U.S. companies to achieve ISO 9001 certification, the strictest of the ISO standards. Although Data Instruments was officially incorporated in 1977, our lineage dates back at least 50 years. It's a pedigree that includes the industry pioneers who created and perfected the technology as we know it. Our ranks include individuals recognized throughout the industry for their contributions to the state of the art (some have been with us for 40 years or more). Our original patents date back 50 years.

When we started making transducers, each was hand-crafted at a cost that limited their use to aerospace or military applications. Since then, we've introduced design innovations and manufacturing refinements that allow us to meet the most demanding requirements at a fraction of their former cost. Today, we produce hundreds of thousands of high-quality transducers a year in our ISO-9001-certified manufacturing facilities in Acton, MA and Sunnyvale, CA. Millions currently are performing in continuous-duty applications around the globe. Typically they outlast the systems they support.

Data Instruments' corporate headquarters in Acton, MA.

Position-Sensing Transducers

Our linear and rotary position sensing transducers include a wide range of contact and noncontact position sensors employing both potentiometric and inductive technologies. Standard stroke lengths range from 0.5 to 60 inches. Our linear potentiometers are rated intrinsically safe. They're also CE-rated. Our potentiometers are a cost-saving, space-saving alternative to LVDT and magnetorestrictive devices. For example, DC Hydrastar® has the largest usable body-to-stroke-length ratio of any noncontact, in-cylinder position sensor available. DI position transducers offer a choice of high-level DC, current, or voltage output.

Stainless Steel Pressure Transducers

The unique design of our stainless steel pressure transducers has elevated quality and reliability well beyond accepted standards. Our bonded semiconductor strain-gauge technology and stainless steel diaphragms withstand the harshest conditions, including corrosive media. Laser-trimmed and tested, they are fully calibrated and temperature-compensated to assure long-term reliability and accurate performance. DI stainless steel pressure transducers can survive more than 160 million full-pressure cycles and still retain their rated accuracy. They are available in gauge, absolute, sealed, and differential models for pressure ranges from 0-5 to 0-20,000 psi.

Micromachined Silicon Pressure Sensors

DI's silicon-based micromachined pressure sensors are low-cost miniature sensors with ranges from 1" H_2O to 150 psi. Small enough to mount directly on printed circuit boards, they're ideal for applications ranging from OEM medical and environmental instrumentation to respirators, cleanrooms, and HVAC equipment. The Sursense™ models employ proprietary DSC (Dynamic Self Compensation) technology for very low pressure ranges of 0-1, 0-5, 0-10, 0-20, and 0-30" H_2O. They can be mounted in any position, because they're not position-sensitive. DSC also eliminates offset errors due to long-term drift.

Detector Safety Light Curtains

Detector light curtains prevent injury by shielding operators and passersby from machine hazards with a harmless and invisible curtain of infrared light beams. Any intrusion signals the machine to stop. Our light curtains have been protecting people for over 25 years. With tens of thousands installed, we're the acknowledged leader in industries known for having some of the world's toughest safety standards.

Global Network

With our global distribution network and technical centers in Germany, France, and Japan, you can expect applications assistance, on-time delivery, and in-depth support virtually anywhere in the world.

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WWW: http://www.datainstruments.com

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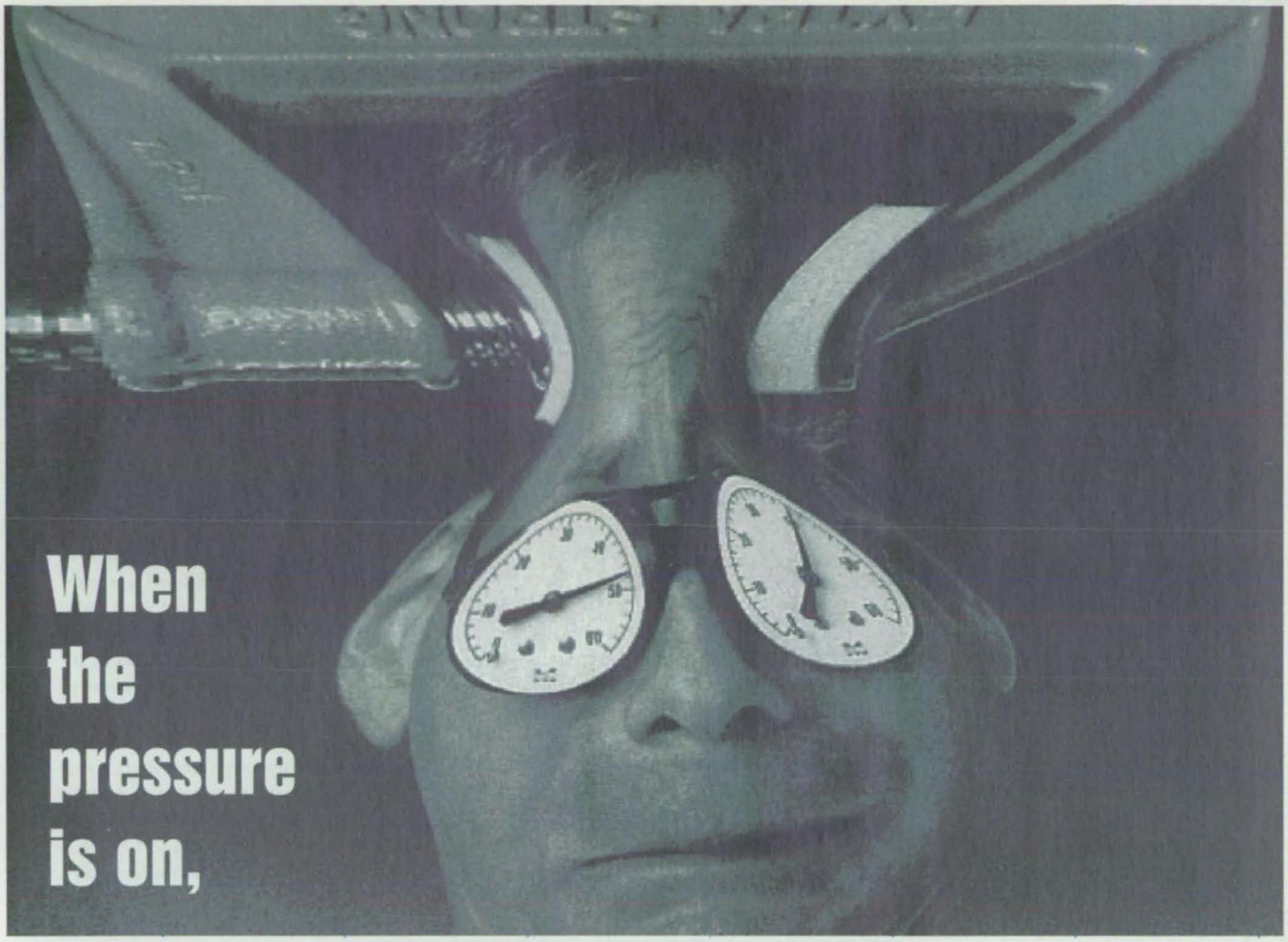

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Data Instruments works best under pressure.

When the pressure's on, there's no substitute for experience-based solutions. Our applications engineers have been solving **pressure sensor** problems for over 30 years. That means expert help is only a phone call away.

The unique design of our pressure sensors has elevated quality and performance well beyond accepted standards. And our volume manufacturing technology keeps unit costs down. So you don't have to sacrifice reliability for price. As for quality, our sensors routinely qualify for "ship-to-stock" approval in some of the world's most critical applications. Millions of our sensors are currently doing continuous-duty around the globe.

Put our experts to work for you.

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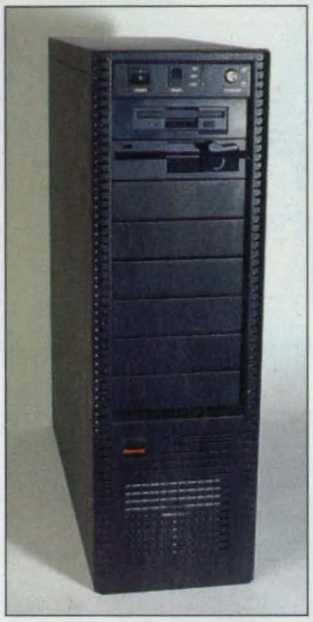
DATA INSTRUMENTS
Acton, MA USA 01720

Microway®

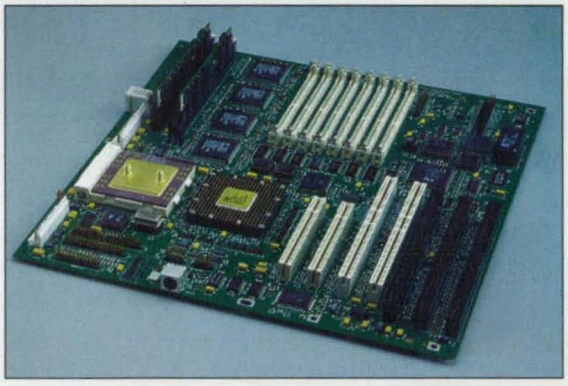
Microway, Inc.

Since 1982, Microway's products and technical support have helped users get more done for less money. Starting with the concept that PCs could use more numeric power, we built a product line and customer base that is now worldwide. The products we sell today use Digital's Alphas that deliver 20,000 times the throughput of the 8087s we started with in 1982. For the last four years, we have been building systems that provide up to 2 gigaflops of throughput using parallel i860s. The 533 MHz DEC Alpha that powers our workstation product line delivers 1 gigaflop by itself! If you have an application that is a big-time number-cruncher or a DSP application which needs more than 32 bits of precision, you should consider a Microway "Screamer" workstation.



One of the problems with getting more done for less is tech support—most expensive PC tools are not supported. Our service starts with the use of the telephone: when you call us you talk to a competent person. Because we appreciate the critical nature of your work, every one of our products comes with free tech support for one year. This means we charge a little more for our production-grade compilers, but they still cost much less than the mini or mainframe tools of the past. Our excellent tech support makes it possible for us to quote your favorite DEC UNIX system, yet also deliver NT and Linux. And we know how to take care of special situations, including rack-mounted industrial-grade systems and RAID-controlled hard disk farms.

Microway's current product line is anchored by NDP Fortran and C/C++, which are available for Pentiums and generate Alpha code for DEC UNIX, NT, and Linux. These translators grew up in the 32-bit x86 DOS Extender markets of the mid-80s, and have been ported to a number of devices and operating systems. From 1986 to 1995, this included Transputer and i860-based cards that employed up to 4 CPUs per card. Using Microway QuadPuters, it became possible to build systems that employed dozens of processors.



In late 1995, we started to deliver Alpha-based workstations with motherboards built in-house. The line will shortly be extended to include parallel solutions and motherboards that have special industrial features.

Our customers for Alpha systems include most of the major universities and government labs. Typical applications run as fast on a 300 MHz 21164 as they do on a Cray Y/MP. Our current 533 MHz product employs faster caches, which help its speed scale with frequency. It delivers 150 Linpack megaflops and dot products that hit one gigaflop.

To take advantage of the Alpha's enormous power, we have developed a scheduler that not only makes it possible to issue four instructions per clock, but to lead loads ahead of their uses. This helps to reduce the latency of caches and memory.

Microway hardware products have always been popular with government, industry, and university researchers. Our i860 powered cards were used to search for oil, improve MRI resolution, do air flow studies on jet engines, and help the NASA SETI project search for extraterrestrial life. An NT-powered Alpha Screamer currently is being evaluated by NASA to control shuttle missions, while a government agency is now using Screamers to run neutron scattering simulations in minutes that used to take days. Our "Screamer" 500 NT workstation, reviewed in July, 1997 *PC Computing*, was rated as the "fastest NT workstation on the planet."

Company History

Microway was founded in 1982 to help scientists and engineers take advantage of the IBM-PC. Our first product was a library, which made it possible to use an 8087 in a PC. We bundled our libraries with 8087s and became one of Intel's largest customers.

Our hardware products included workstations, coprocessor cards, and motherboards. In 1986, we introduced the first 32-bit Fortran to run on an Intel PC. The first PC to hit a megaflop used a Microway/Weitek coprocessor driven by NDP Fortran. Over the years, NDP Fortran has been used to port hundreds of popular mainframe applications, including MATLAB and ASPEN, to Intel-based PCs.

Microway, Inc.
Research Park, Box 79
Kingston, MA 02364
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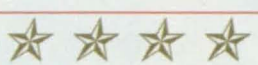
Your applications can now run on "the fastest Windows NT machine on the planet." These include Microsoft Office, Oracle and Netscape; plus engineering and graphics software such as Fortran, C/C++, Visual Basic, Pro/Engineer, Microstation, ANSYS, LAPACK, Gaussian, Softimage and Lightwave. Over the last 15 years we have designed systems for thousands of satisfied customers including many prestigious institutions like NASA and Fidelity Investments. Our technicians are expert at configuring all Alpha operating systems and applications, and you will not find more technically competent sales people anywhere.

System Performance

Microway understands the importance of balancing fast CPUs with equally fast caches, memory and peripherals including SCSI hard drives, 3D graphics cards and RAID solutions. Microway's exclusive 4MB SSRAM cache, fed by a 144-bit wide memory system, boosts performance by up to 30%. Its 64-bit PCI bus is driven by a state-of-the-art Digital chip set that feeds 32- and 64-bit PCI sockets.



Microway's Screamer . . . "is, quite simply, the fastest Windows NT machine on the planet. . . The performance leader."
PC Computing - July, 1997

AlphaPowered™

Numeric Performance

Microway produces one of the finest numeric optimized compilers - NDP Fortran. Since 1986, hundreds of applications have been ported to the X86 with it. On a 600 MHz 21164, a dot product kernel we use for compiler testing achieves a mind-boggling 1128 megaflops!!! Using hand-coded BLA's and FFT's, our new NDP VDSP Library hits 343 megaflops triangularizing dense arrays and performs a 1024 complex FFT in 200 microseconds.

For a complete description of the optimization facilities provided by NDP Fortran or C, our Screamer Systems and motherboard pricing call **508-746-7341** or visit our WEB Site at: **http://www.microway.com**.

Microway®

Technology You Can Count On

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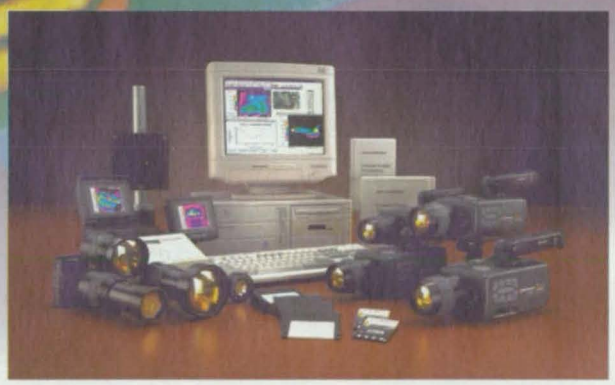

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SolidWorks

SolidWorks Corporation

SolidWorks Corporation is pleased to offer SolidWorks 97Plus, the fourth release of the company's award-winning Windows-native 3D mechanical design software. SolidWorks 97Plus solid modeling software features over 160 customer-driven enhancements including performance optimization for large assemblies, enhanced sweeping and lofting, interactive customizable exploded views, improvements in detailing, and expanded Internet capabilities.

First released in November 1995, SolidWorks software was designed as the first Windows-native 3D mechanical design system for mainstream engineers. Today, SolidWorks is the fastest growing company in the history of the CAD/CAM software industry, and in 18 months of shipment, SolidWorks has received 13 industry awards. With this latest release, SolidWorks continues its commitment to customers, partners, and resellers in bringing production solid modeling to the mainstream.

Assemblies & Performance

SolidWorks 97Plus performance improvements include optimization for large assemblies. Configuration support has been extended to include enhanced sub-assembly interaction. With SolidWorks 97Plus, multiple configurations can be defined beyond the assembly level down to multiple configurations for sub-assemblies. SolidWorks 97Plus also incorporates:

- Customized exploded views, allowing users to better communicate the assembly nature of a design.
- A Weld Wizard – easy-to-use, step-by-step guide to mating multiple parts which are to be welded.
- Support for multi-user environments including part locking.

SolidWorks Corporation
150 Baker Avenue Ext.
Concord, MA 01742
Tel: 508-371-2910
Fax: 508-371-7303
e-mail:
info@solidworks.com
WWW:
www.solidworks.com

Part Modeling

SolidWorks continues to add even more powerful part modeling improvements including enhanced sweeping and lofting using guide curves, enabling users to create freeform highly stylized parts.

Additional part modeling enhancements include:

- The ability to add 3D annotations to parts and assemblies.
- The selection of silhouette edges to reference geometry.
- Automatic creation of bend reliefs for sheet metal design.
- The ability to create a rounded face using the "dome" function.
- A Feature Toolbar to facilitate user interaction in creating features quickly and easily.
- Shrinkage control for mold makers.
- Face filleting.
- Patterning of patterns/mirror of patterns.

Drawings

With more than 65 enhancements in detailing capabilities, users now have additional control over drawings. Key features include:

- The FeatureManager design tree now available in drawings.
- A new detailing toolbar for easy access to commonly used features.
- Import of 3D annotations from the model or assembly.
- The ability to create hyperlinks to notes, other files or Internet-related materials.
- Selection of multiple shapes for balloons.
- Creation of rotated text.
- Multi-sheet support; cut and paste views between sheets.

Ease-of-Use Enhancements

With each release of its mechanical design system, SolidWorks continues to improve its ease of use. In SolidWorks 97Plus, the user interface has been further simplified to include enhancements to the FeatureManager design tree; a modeling and detailing toolbar; and a rollback bar that allows users to investigate the design sequence by dragging the bar step by step. Enhanced viewer diagnostics, such as the "what's wrong" option in the FeatureManager, allow users to better understand and evaluate the design intent. SolidWorks 97Plus also features a concurrent usage option that allows multiple users to work on an assembly at the same time.

Internet Support

Designed with the Internet in mind, SolidWorks 97Plus makes it easy to share designs in native SolidWorks format, within and across engineering organizations. With SolidWorks 97Plus, users can add hyperlinks directly to parts, drawings, or assemblies, allowing users to link automatically to the Internet or externally referenced files to view design-related information. SolidWorks also has introduced a free Internet plug-in product, the SolidWorks 97Plus Viewer, concurrent with the release of SolidWorks 97Plus, to allow non-SolidWorks users to review native design data. By using native data, users can be sure they are reviewing the most current version of the design without having to worry about intermediate file transfer formats.

About SolidWorks

SolidWorks Corporation develops and markets mechanical design software products for Windows. SolidWorks was founded in 1993 with the mission to bring production solid modeling to the desktop of every engineer. SolidWorks has offices worldwide and distributes its products through a network of 150 resellers in 43 countries.

Circle No. 623

Why do more mechanical design engineers choose SolidWorks™?

Results. Our production solid modeling solutions help thousands of customers worldwide operate more efficiently with faster time-to-market – from Alcoa in the US to Sindo-Ricoh in Asia. With this kind of success, it should come as no suprise that SolidWorks experienced the best first year of any CAD company in history, with more first year revenue than PTC and Autodesk – combined.

Why the move to SolidWorks? We provide the highest quality solid modeling and mechanical design solutions in the market. Bar none. Our products are consistently released on time. They move our customers quickly into production. And offer Windows®-native ease-of-use, 100% editability for design flexibility, and productivity gains up to 60%. All for only $3,995 (USD)*.

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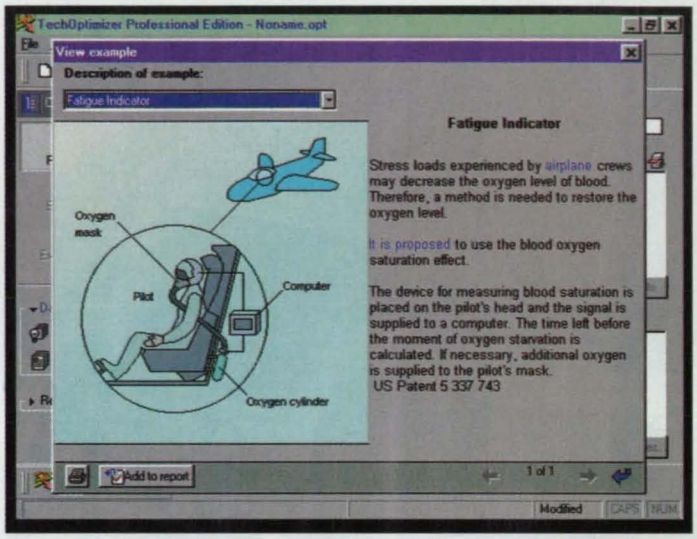
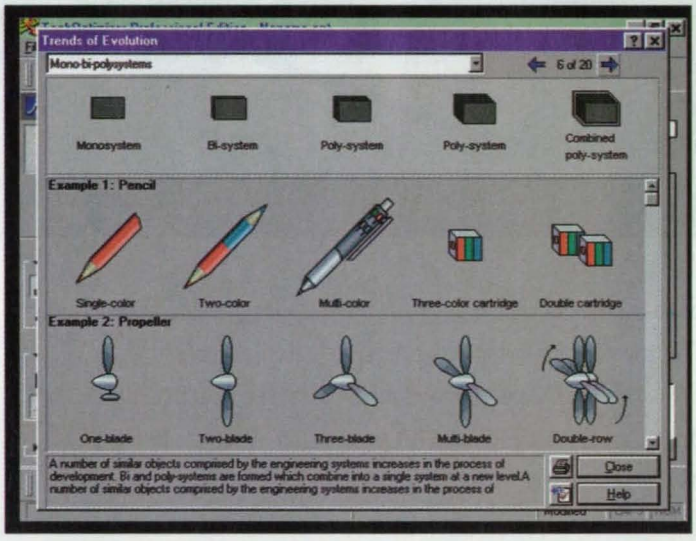
Invention Machine Corporation

In 1982, Dr. Valery Tsourikov developed the first Computer-Aided Innovation application by integrating artificial intelligence with the Theory of Inventive Problem Solving (TIPS/TRIZ).

Founded in 1992, Boston-based Invention Machine Corporation is the leading provider of software tools that enable engineers, scientists, and technologists to extend their knowledge and capability to solve technical problems by generating innovative ideas. Invention Machine's revolutionary software tools provide users with a new approach for the development of high-quality, well-designed products and processes. Invention Machine Corporation now has offices in Stockholm, Sweden and Tokyo, Japan. With over 180 employees and affiliates worldwide, Invention Machine Corporation offers complete engineering solutions to any organization.

Invention Machine offers **engineering consulting and training** to our clients.





cost-conscious solutions.

Some of the benefits of TechOptimizer Professional include the following: enables corporations to develop innovative solutions without compromise; helps engineers to create high-quality engineering solutions; increases productivity; avoids expensive errors in the early stages of design; and stay ahead of the competition.

TechOptimizer Professional is used once a market/manufacturing need has been identified. It analyzes the system to correctly state engineering problems. It is also used to solve the identified engineering challenge which can then be further developed by using engineering design tools.

System Requirements

The system requirements are a 486/66 MHz or better IBM-compatible computer, Windows® 95 or Windows® NT, 16MB RAM, and 70 MB free hard drive. The price is $7,500.

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TechOptimizer™ Professional Edition

TechOptimizer™ Professional Edition is a **new, innovative** software tool that is designed to work with engineers in the conceptual stages of product or process development. TechOptimizer Professional Edition defines a new category of engineering software: Computer-Aided Innovation (CAI). This software tool helps users to correctly state and solve their engineering problems across a number of fields of engineering. Tech Optimizer Professional Edition offers a breakthrough process for strategic and guided thinking to create innovative and

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"Having this software is like having your own personal brainstorm power."

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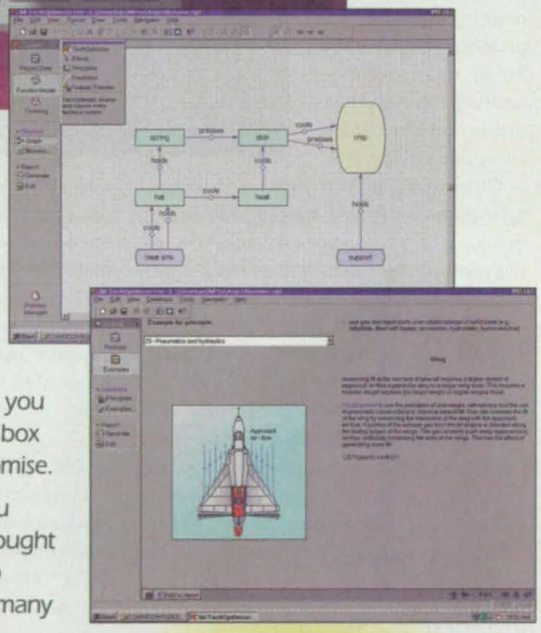

TechOptimizer Professional Edition is the only software product that assists you in the conceptual stage of design. This product offers you a systematic approach for thinking outside the box and generating new solutions without compromise.

TechOptimizer Professional Edition helps you out-think your competition by guiding your thought process. This unique software tool helps you to correctly state and solve your problems across many fields of engineering.

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The Company

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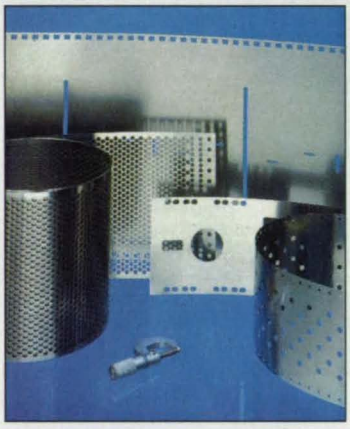

World leaders in aerospace, telecommunications, electronics, imaging, packaging, and pharmaceuticals, as well as consumer products, rely on systems utilizing our products. BTI is noted for its rapid, accurate, and reliable manufacturing and attention to customer service.

Our organization is structured to provide design assistance, specialized components, and prototypes, in addition to high-volume production that may be part of long-term blanket contracts.

The engineering staff at BTI combines expertise in metallurgical, mechanical, and industrial engineering with years of applications experience to help our customers achieve optimal performance from their metal belt or drive tape-based system. Detailed design engineering and drawing generation is usually completed by BTI or BTE at no charge to the customer.

Why Belt Technologies' Products are Better

Metal belts and drive tapes from BTI have several unique and important characteristics simply not found in other drive components including:

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- They are thermally and electrically conductive
- They operate in hostile environments
- They are quiet and generate no cordal vibration.

Typical dimensions range from 0.100" wide to 32.0" wide and from 0.002" thick to 0.030" thick. Lengths range from 9.0" to hundreds of feet. Remember, these are only typical dimensions.

Perforations and Coatings

Metal belts can be designed to incorporate a broad range of coatings, perforations, or attachments in countless combinations. A few applications for these belts include nested parts conveying, high-speed packaging, oriented component transfer, vacuum conveying, indexed assembly and inspection, and automated cleanroom transfer lines.

Drive Tapes

Frequently, BTI designs and fabricates metal strips with end attachments which we call "drive tapes." These drive tapes exhibit the same desirable characteristics as our metal belts, but are used in very different situations.

Specialized end attachments interface with customer-designed hardware, such as shafts or carriage assemblies, to transmit motion – typically reciprocating – in zero or near-zero backlash applications. Some of the more common installations of drive tapes can be found in high-resolution plotters or in imaging equipment of various designs.

Like metal belts, drive tapes are designed and manufactured across a broad range of sizes utilizing many high-strength, high-quality alloys.

Precision Pulleys

A precision metal belt or drive tape cannot deliver the accuracy, repeatability, or longevity it is capable of providing if it is operating on substandard, inadequate pulleys. BTI manufactures pulleys to exacting standards in order to assure design objectives are achieved and system integrity is maintained.

Pulleys may be smooth-faced, to be used as idlers or as driving pulleys in friction drive applications, or they may incorporate timing teeth or pockets to be used in indexing or trimming applications. General designs and sizes are as varied as are our metal belts.

BTI currently has two pulley patents and two more are pending. One of the existing patents is applicable to our style that uses precision ball bearings as timing teeth. The other patent applies to our "Independently Steerable Pulley (ISP)." This ISP allows the user to make belt steering adjustments directly from the pulley without having to adjust the pulley shaft.

The ISP, for the first time, enables the engineer to mount several pulleys on a common shaft and steer all independently. The ISP also enables the engineer to design into the system real-time automatic belt tracking.

Company Commitment

Belt Technologies, Inc. has been committed to assisting our customers in improving their designs by employing metal belt technology for over two decades. Metal belts and drive tapes from BTI truly do drive improvements in productivity in a cost-effective, proven fashion. We encourage potential new users of this technology to contact us for more detailed information and for design assistance.

Belt Technologies, Inc.
PO Box 468
Agawam, MA 01001
Tel: 413-786-9922
Fax: 413-789-2786

Circle No. 615

The MathWorks, Inc.

The MathWorks, Inc., located in Natick, Massachusetts, was established in December 1984 to develop and market interactive engineering and scientific software products. The founders of The MathWorks recognized the need among engineers and scientists for more powerful computing environments beyond those represented by Fortran and C. In response to that need, they combined their expertise in mathematics, engineering and computer science to develop MATLAB®. MATLAB is a high-performance, technical computing environment that provides comprehensive math and graphics, specialized application toolboxes, and a powerful structured programming language. MATLAB offers hundreds of convenient, built-in functions that users can customize and extend as needed. Users can also link in their existing C, C++, and Fortran programs. The MATLAB Compiler, and C and

The MathWorks, Inc.
24 Prime Park Way
Natick, MA 01760-1500
Tel: 508-647-7000
Fax: 508-647-7101
Email:
info@mathworks.com
WWW:
www.mathworks.com

C++ Math Libraries allow users to automatically convert their MATLAB programs into portable C or C++ code for standalone applications that run outside of the MATLAB environment. MATLAB files and user-written applications are portable across PC, Macintosh, and UNIX workstation platforms.

Simulink®, built on the MATLAB technical computing environment, is an interactive system for analyzing, modeling, and simulating dynamic nonlinear systems. Stateflow™, a major new product addition to the Simulink environment, is a graphical tool for designing complex reactive, event-driven systems based on finite state machine theory. The combination of Simulink and Stateflow offers practical design and analysis tools for such industries as automotive, aerospace, and communications.

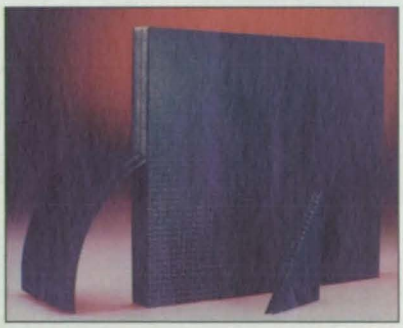
MATLAB Toolboxes and Simulink Blocksets extend the power of MATLAB by providing algorithms and functions developed by experts in digital signal processing, control system design, image processing, symbolic math, finance, statistics, mapping, neural networks, system identification, optimization, and other application areas.

NASA engineers and scientists nationwide have adopted MATLAB for several mission-critical research and design projects, including the next-generation High Speed Civil Transport.

Circle No. 614

Foster-Miller, Inc.

Foster-Miller is a technology development organization. We use our engineering capabilities to develop unique solutions to difficult technical problems. Once a solution is found, we build it, test it, and implement it. We've been doing this for 40 years, with clients in government, utilities, and commercial environments. When applicable, we form new companies, partnerships, or joint ventures to commercialize our new technologies. In the past five years, six new businesses have been created and many strategic alliances have been formed. Our track record of success in creating new products continues. Here are two examples:



Aztex, Inc. recently was formed as an independent venture to manufacture and sell a unique line of composite reinforcement products and materials. Z-FIBER and X-COR technologies originally were developed through Navy and Air Force SBIRs. Z-FIBER is a superior reinforcement and attachment technique that significantly increases the strength and safety of composite structures. X-COR is a new sandwich structure material that is lighter, stronger, and more durable than honeycomb or aluminum cores. These products are being implemented in aircraft, with development underway in automotive, marine, medical, and sporting goods markets.

Foster-Miller
350 Second Ave.
Waltham, MA 02154-1196
Tel: 781-684-4078
Fax: 781-290-0693

Sensiv, Inc., a joint venture between Foster-Miller and Isorad of Israel, was formed to commercialize our line of remote infrared fiber optic spectroscopy systems and laboratory accessories. These systems provide the precise chemical composition and analysis capabilities of laboratory equipment in a rugged and remote package. They can be taken into the field or onto the shop floor to provide accurate, real-time readings of chemical content. Several products have been developed and are being marketed in environmental, paints and coatings, pharmaceuticals, food processing, and other areas.

Other recent commercializations include:

- High barrier plastics processing
- Environmental cleanup technologies
- Smart sensors
- Specialized service robots

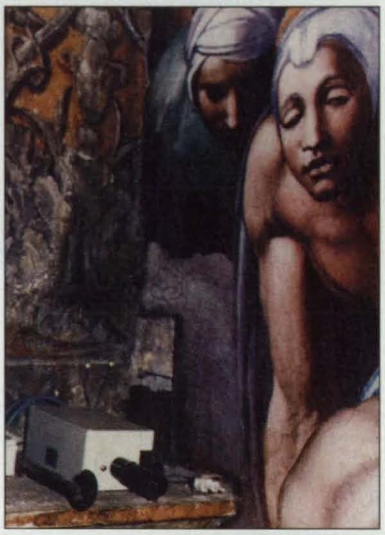
Bring us your challenges, your goals, and your opportunities. We'll continue to raise the bar on technological innovation.

Circle No. 613

EdgeTech

EdgeTech Moisture and Humidity Systems traces its history to 1963, when the company existed as Cambridge Systems. In 1965, EG&G acquired Cambridge Systems (Atmospheric Products) and Geodyne Corporation (Marine Oceanographic Products), creating EG&G Environmental Equipment Division (EED). As the EED grew, it evolved into two separate divisions: EG&G Moisture and Humidity Systems and EG&G Marine Instruments. In 1995, both divisions were acquired and became EdgeTech, a wholly-owned subsidiary of Victoreen Inc.

EdgeTech Moisture and Humidity Systems designs, manufactures, and markets sensor-based instrumentation that measures moisture and humidity in air and other gases. EdgeTech products include benchtop and transmitter chilled mirror hygrometers as well as electrolytic instruments.



EdgeTech Moisture and Humidity Instruments are used in applications that run the gamut from dynamometer test facilities at Jaguar, Ford, and GM, to NOAA hurricane hunter aircraft, to cleanrooms at Intel and Hewlett-Packard. EdgeTech hygrometers also are included in thousands of other applications where accurate, reliable measurements of humidity are required; such applications include The Sistine Chapel (see photo), the NASA space shuttle, and the Russian MIR space station.

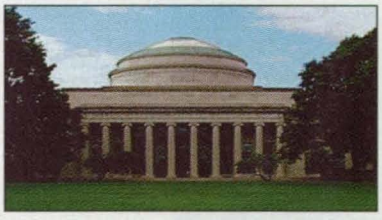
EdgeTech Moisture and Humidity Systems continues to demonstrate its commitment to its customers with the introduction of the Model 2003 Sensor.

EdgeTech
455 Fortune Blvd.
Milford, MA 01757
Tel: 508-478-9500
Fax: 508-478-1456
e-mail:
sales@edgetech.com
WWW: www.edgetech.com

Circle No. 611

Massachusetts Institute of Technology (MIT) Center for Advanced Educational Services (CAES)

The MIT Center for Advanced Educational Services creates and distributes educational products and services worldwide. The Center offers a variety of on-campus and off-campus programs, both credit and non-credit, to meet the evolving needs of undergraduate, graduate, and professional learners.



The Advanced Study Program (ASP), within CAES, provides lifelong learning opportunities for working professionals. On-campus ASP Fellows can pursue individualized, self-directed coursework. Courses delivered via the MIT Virtual Campus Learning System™ allow groups of learners to participate at their location through the use of the Internet, the World Wide Web, videoconferencing, fax, videotapes, and printed materials.

The Hypermedia Teaching Facility (HTF), another group within CAES, develops web-based courses for the MIT community and for distance learning applications. Web-based courses typically include e-mail, mailing lists, discussion groups, links to Internet and WWW resources, digitized video, animation, photos, figures, charts, and search utilities.

In its 48th year, the **Professional Institute** provides educational experiences for professional women and men who wish to keep up with developments in technology, science, and management.

The **Center for Educational Computing Initiatives** is home to several independent, collaborative research groups aiming to advance state-of-the-art and practical use of computation and communication technologies for learning and teaching.

MIT CAES
Kris Kipp, Marketing Mgr.
77 Massachusetts Ave.,
Room 9-234
Cambridge, MA 02139
Tel: 617-253-7408
e-mail:
caes-courses@mit.edu
WWW: www-caes.mit.edu

Circle No. 612

TECHNOLOGY BUSINESS RESOURCE GUIDE

A select list of federal, state, and community offices and programs

FEDERAL LABORATORY CONSORTIUM (FLC) *is the nationwide network of Federal Laboratories that provides the forum to develop strategies and opportunities for moving government technologies to the marketplace.*

The Federal Laboratory Consortium for Technology Transfer (FLC) consists of more than 700 member research laboratories and centers from 16 federal departments and agencies. It has been in existence since 1974. To accomplish its mission, the FLC supports the technology transfer needs of its members and those interested in the research and technology results. The passage of the Stevenson-Wydler Technology Innovation Act (PL 96-480) in 1980 provided increased stimuli for the development and growth of the FLC. The Federal Technology Transfer Act (PL-99-502) in 1986 continued the impetus by setting further guidelines for the transfer of technology. This same law also provided the FLC with a Congressional charter defining its role and responsibilities.

In order to administer its affairs and services, the FLC is divided into six geographical regions, Northeast, Mid-Atlantic, Mid-Continent, Mid-West, Southeast, and Far West. Each region has a regional coordinator and a deputy coordinator at member laboratories that serve as the operational link between the FLC and potential outside technology interests.

The FLC Northeast Region encompasses all of the New England states, New York, New Jersey, and Puerto Rico.The list below provides points of contact for the FLC member laboratories and their representatives in the six New England states. These representatives are your FLC Northeast Region gateway to technology transfer research and development opportunities within the federal laboratories in the region.

POINTS OF CONTACT

FLC Northeast Regional Coordinator

Dorry Tooker
Brookhaven National Laboratory
516-344-2078
516-344-3729, fax

FLC Northeast Region Deputy Coordinator

Peter Sparacino
FAA William J. Hughes Technical Center
609-485-5430, phone
609-485-6509, fax

Barbara Brown
U.S. Department of Energy
EPA - Region 1
JFK Federal Building
Boston, MA 017942
617-565-3397, phone
617-565-3415, fax

Cmdr. Michael Curley
Naval Submarine Medical Research Laboratory
Code 01
Groton, CT 06349-5900
203-449-3265, phone
203-449-4809, fax

Ms. Noreen Dimond
Air Force
Phillips Laboratory
Geophysics Directorate,
29 Randolph Road
Hanscom AFB,
MA 01731-3010
617-377-3608, phone
617-377-5974, fax

Dr. Murray P. Hamlet
U.S. Army Research Institute of Environmental Medicine
Attn: SGRD-UE-RP
Natick, MA 01760-5007
508-233-4865, phone
508-233-5298, fax

Major Audie Hittle
Air Force Electronic Systems Center
HQ ESC/XPR
50 Griffiss St.
Hanscom AFB,
MA 01731-1624
617-271-4717, phone
617-271-4585, fax

Ms. Margaret McNamara
Office of Res. & Technology App.
Naval Undersea Warfare Center, Div. Newport
1176 Howell Street,
Bldg. 108, Code 10
Newport, RI 02841
401-841-7279, phone
401-841-1725, fax

Mr. Jan McNutt
U.S. Coast Guard
R&D Center
1082 Shennecossett Road
Groton, CT 06340-6096
203-441-2670, phone
203-441-2792, fax

Mr. Richard Michaud
DOE-Boston Operations Office
U.S. Department of Energy
One Congress Street
Boston, MA 02114
617-565-9713, phone
617-565-3723, fax

Ms. Lynn Murray
DOT/Volpe National Transportation Center
55 Broadway,
Kendall Square
Cambridge, MA 02142
617-494-2224, phone
617-494-3731, fax

Dr. Joyce Nagle
U.S. Army Cold Regions Research and Engineering Laboratory
Attn: CECRL-PP
72 Lyme Road
Hanover, NH 03755-1290
603-646-4161

Mr. Allen Peterson, Jr.
Northeast Fisheries Science Center
Woods Hole Laboratory
166 Water Street
Woods Hole, MA 02574
508-548-5123, phone
508-548-5124, fax

Mr. Robert L. Rosenkrans
U.S. Army Soldier Systems Command (NRDEC)
Attn: SSCNC-AE
One Kansas Street
Natick, MA 01760-5015
508-233-5296, phone
508-233-5086, fax

Ms. Rosemary Salem
Navy Clothing & Textile Research Facility
P.O. Box 59
Natick, MA 01760-2490
508-233-4172, phone
508-233-4783, fax

Federal Agencies

Department of Energy
Boston, MA
617-565-9700

Department of Labor
Boston, MA
617-565-2072

Environmental Protection Agency
Boston, MA
617-565-3400

Federal Aviation Administration
Burlington, MA
617-561-5700

Federal Communications Commission
Quincy, MA
617-770-4023

Federal Emergency Management Agency
Boston, MA
617-223-9577

Federal Trade Commission
Boston, MA
617-565-7240

Food and Drug Administration
Stoneham, MA
617-279-1720

Information Resources Management Service
Boston, MA
617-565-5750

International Trade Administration
Boston, MA
617-565-8563

Interstate Commerce Commission
Boston, MA
617-424-5160

National Institute for Standards and Technology Manufacturing Extension Program
800-MEP-4MFG

Occupational Safety and Health Administration
Boston, MA
617-565-7164

US Agency for International Development
Washington, DC
202-647-9620

US Customs Service
Boston, MA
617-565-6300

US Department of Commerce
Boston, MA
617-565-8576

US Dept. of Transportation
Cambridge, MA
617-494-2000

US Small Business Administration
Boston, MA
617-565-5561

US SBA – Springfield Office
Springfield, MA
Harry Webb
413-785-0268

US SBA – Augusta
Augusta, ME
Leroy Perry
207-622-8378

US SBA –Concord Office
Concord, NH
William Phillips
603-225-1400

US SBA – Montpelier
Montpelier, VT
Kenneth Silvia
802-828-4422

US SBA – Hartford
Hartford, CT
Jo-Ann Van Vehten
860-240-4670

US SBA – Providence
Providence, RI
Joseph Loddo
401-528-4580

Small Business Development Centers

SBDC locations offer free and low-cost services, seminars and workshops, including consulting services, financial projections, business planning and marketing help. The SBDC links businesses with higher education, state and federal programs as well as other businesses.

Small Business Development Center State Administrative Office
Amherst, MA
John Ciccarelli
413-545-6301

SBDC – Central MA
Worcester, MA
Laurence Marsh
508-793-7615

SBDC – Metro Boston
Chestnut Hill, MA
John McKiernan
617-552-4091

SBDC – North Shore
Salem, MA
Frederick Young
508-741-6343

SBDC – Southeastern MA
Fall River, MA
Clyde Mitchell
508-673-9783

SBDC – Western MA
Springfield, MA
Dianne Doherty
413-737-6712

SBDC – Capital Formation Service
Chestnut Hill, MA
Donald Reilly
617-552-4091

SBDC – Minority Business Assistance Center
Boston, MA
Joseph France
617-457-4444

SBDC – International Trade Program
Boston, MA
617-367-1830

SBDC – Connecticut
Storrs, CT
John O'Connor
860-486-4135

SBDC – Maine
Portland, ME
Charles Davis
207-780-4420

SBDC – New Hampshire
Durham, NH
Lyndon Goodridge
603-862-2200

SBDC – Vermont
Rutland, VT
Donald Kelpinski
802-728-9101
802-728-3026, fax

SBDC – Rhode Island
Smithfield, RI
Douglas Jobling
401-232-6111

ADDITIONAL ASSISTANCE
(Arranged By State)

Center for Technology Commercialization – HQ
NASA's Northeast Regional Tech Transfer Center
Westborough, MA
James Dunn
508-870-0042

CTC- Massachusetts
Westborough, MA
Peter McDavitt
508-870-0042

NASA Business Outreach Program
Westborough, MA
Glenn Wright
800-861-5037

The Massachusetts Technology Collaborative *is an economic-development organization focusing on assisting technology-intensive enterprises. The collaborative focuses not only on traditional high-tech fields but on novel applications of technology to other industries as well. For more information contact*
Joseph Alviani.
508-870-0312

The Massachusetts Manufacturing Partnership *works with companies to help them adopt new manufacturing practices and technologies. The partnership develops projects that increase quality, streamline processes, strengthen employee performance, and enhance products. For more information contact*
Cynthia Rider.
617-292-5100

Massachusetts Centers of Excellence Corporation
Boston, MA
Gary Glenn
617-727-7430

MIT Industrial Liaison Program
617-253-2691, phone
617-253-0002, fax

Massachusetts High Tech Council
Howard Foley
617-890-6482

MIT Enterprise Forum
Trish Fleming
617-253-8240

Massachusetts Biotechnology Council
Cambridge, MA
Janice Borque
617-577-8198

Massachusetts Computer Software Council, Inc.
Boston, MA
Joyce Plotkin
617-437-0600

Massachusetts Office of Business Development Main Office
John Regan
617-727-3206

Greater Boston –
Gordon Carr
617-727-1515

Northeastern MA –
508-970-1193

Western MA –
Kent Lage
413-784-1580

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

M I T C A E S

CENTER FOR ADVANCED EDUCATIONAL SERVICES

Get The MIT Career Advantage Join the Advanced Study Program

The Advanced Study Program (ASP) at MIT provides lifelong learning opportunities to meet your needs at every stage of your career. Whether you participate on-campus or at a distance, as an ASP Fellow you will:

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- **Earn MIT credit for successfully completed coursework**
- **Learn from world renowned MIT professors**
- **Gain new perspectives on emerging technologies**
- **Grow professionally through dynamic interaction with other ASP Fellows from around the world**

The Ultimate learning Experience on-campus at MIT

As an ASP on-campus Fellow, you can explore the rich set of educational and recreational resources at MIT. We offer programs during three semesters: Fall, Spring, and Summer. You may also work on a self-guided study under close supervision of an MIT faculty member. You will have an on-campus office, access to private computers, a videotape library, and use of all other MIT facilities.

The MIT Virtual Campus Learning System™ allows groups of people to participate in the Advanced Study Program from their location.

A combination of communication technologies is used for course delivery including videoconferencing, satellite, internet videotapes, e-mail, and fax. Access is made easy by systems set up at your facility or a nearby site reducing time away from your job, your family, and also saving transportation and housing costs.

Some of the course offerings that are available through the MIT Virtual Campus Learning System™ are:

- **Advanced Marketing Management**
- **Dynamic Strategic Planning**
- **Economic Concepts for Engineers and Managers**
- **Management of Technological Change**
- **Modeling and Simulation of Dynamic Systems**
- **Project Management**
- **Welding and Joining Processes**
- **Management of Manufacturing**

Courses can also be tailored to meet your organizational needs

Whether you choose the on-campus learning experience or the convenience of taking courses at your workplace, you and your organization will benefit from the expertise that MIT can offer. Call, write, or visit our Website today regarding educational opportunities in the Center for Advanced Educational Services.

Diane Molino-Fox, Marketing Assistant
Massachusetts Institute of Technology, 77 Mass. Avenue, Room 9-335, Cambridge, MA 02139-4307
WWW: http://www-caes.mit.edu • **Email:** CAES-ASP@mit.edu • **Phone:** 617-253-6128 • **Fax:** 617-258-8831

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Central MA –
Charles Miller
508-792-7506

Southeastern MA –
Larry Cameron
508-997-3067

Massachusetts Technology Development Corporation
Boston, MA
John Hodgman
617-723-4920

Worcester Business Development Corporation
Worcester, MA
William Purcell
508-753-2924

***Maine** Office of Business Development*
Department of Economic and Community Development
Diane Kew
207-287-3153

Maine Science and Technology Foundation
Augusta, ME
Claire Collins
207-621-6350

Maine Aquaculture Innovation Center
Orono, ME
Michael Hastings
207-989-5310

University of Maine
Department of Industrial Cooperation
Orono, ME
James Ward, IV
207-581-2200

Northern Maine Technical College Business and Industry Services
Presque Isle, ME
207-768-2768

Center for Technology Transfer – Maine
Portland, ME
Robert Dalton
207-780-1744

***Connecticut** Economic Resource Assistance Center*
Hartford, CT
Rita Zangari
800-392-2122

Connecticut Innovations, Inc.
Rocky Hill, CT
Pam Hartley
203-563-5851, phone
203-563-4877, fax

Connecticut Technology Association Inc.
Farmington, CT
Elliot Schulman
860-676-8442

***Rhode Island** Economic Development Corporation*
Providence, RI
Carol Malysz
401-277-2601, phone
401-277-2102, fax

Rhode Island Technology Transfer Center
Providence, RI
Don Steinman
401-421-1556

***New Hampshire** Technical College*
Concord, NH
603-225-1800

University of New Hampshire Industrial Research Center
Durham, NH
Henry Mullavey
603-862-0123, phone
603-862-0329, fax

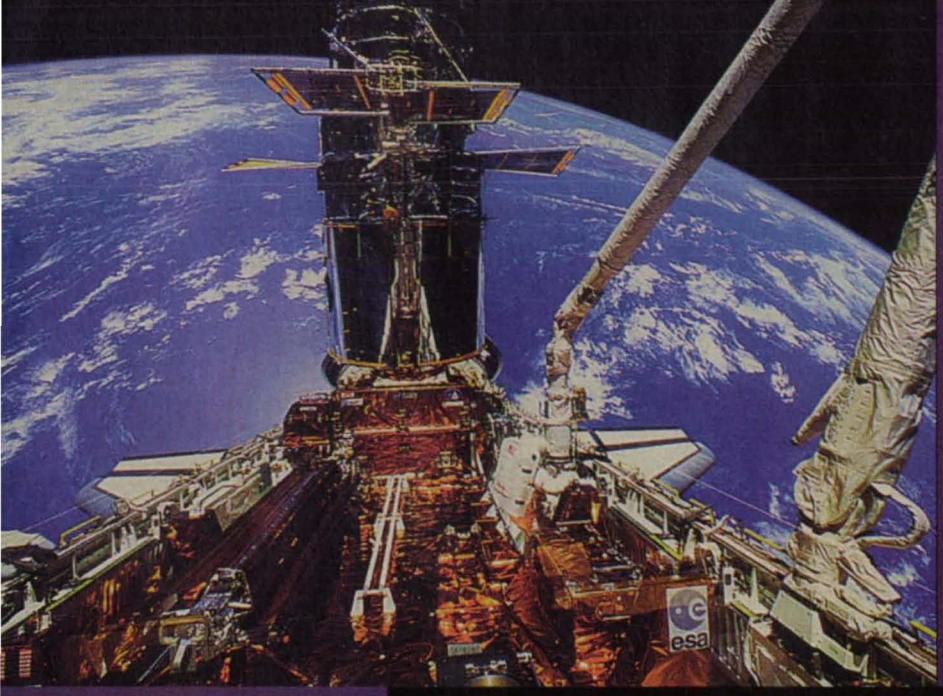
Dartmouth College Technology Transfer Office
603-646-3027, phone
603-646-3670, fax

CTC – NH/VT
Nashua, NH
Glen Wright
800-861-5037

***Vermont** Department of Economic Development*
Montpelier, VT
800-341-2211

Greater Burlington Industrial Corporation
Burlington, VT
Norbert Lavigne
802-862-5726

The New England Council *is comprised of businesses and institutions dedicated to improving the economic vitality in the six-state region. The Council provides New England organizations the opportunity to speak with a united voice to ensure the region's competitive position. For more information contact* Larry Zabar.
617-437-0304



WORLDS OF POSSIBILITY

Are You . . .

Stymied By Technological Challenges?

•

Seeking Specific Technologies fo New or Improved Products?

•

Suffering From All-Too-Limited R&D Budgets?

CTC CAN HELP

Since 1991, CTC Has:

Completed over 60 partnership agreements between federal laboratories and private companies

•

Executed over 45 licenses for utilizing federal technologies

•

Assisted a diverse group of companies, ranging from start-ups to Fortune 500 members, in raising over $1.5 billion in new contracts

The Center for Technology Commercialization (CTC) assists industry to obtain an commercialize NASA, Federal Laboratory, University and privately-owned technologies. CT operates NASA's Northeast Regional Technology Transfer Network of 8 satellite office throughout the Northeast. This extensive network of scientists, high-tech business manager and entrepreneurs -- in collaboration with NASA's other Technology Transfer Centers -- ca apply vital resources to your company's efforts to acquire & commercialize new technology.

CTC: A POWERFUL RESOURCE FOR AMERICAN BUSINESS

Every year, thousands of process and product innovations developed by NASA and th Federal Labs go largely undiscovered by commercial companies. Let CTC connect you wit these latest technologies.

Center for Technology Commercialization
1400 Computer Drive
Westborough, MA 01581-5043
PHONE: 508.870.0042
Fax: 508.366.0101
Http://www.ctc.org
email: info@ctc.org

BRINGING THE BEST OF NASA TECHNOLOGY DOWN TO EARTH

For More Information Circle No. 549

MASSACHUSETTS OFFICE OF BUSINESS DEVELOPMENT

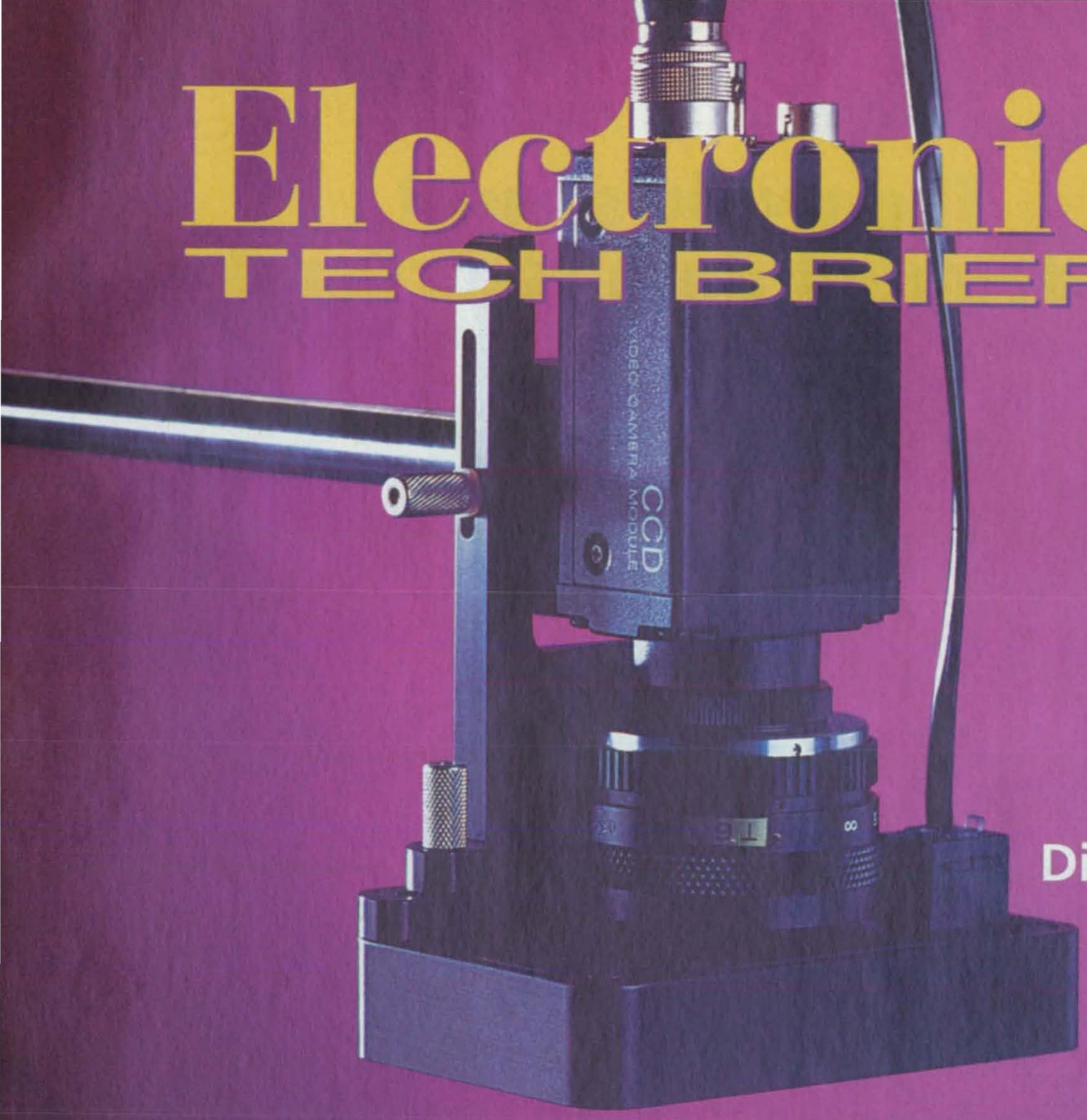
The Massachusetts Office of Business Development (MOBD) promotes job creation, economic development and expansion of the state's economy by capitalizing on the technical, industrial, educational, manufacturing, cultural and geographic advantages of the Commonwealth. MOBD's five regional business centers provide a full array of services which include:

- General information on starting a business in Massachusetts;
- Access to federal, state, local, and private financial resources;
- Site selection service, with focused industry and geographic specialization;
- Facilitation of the regulatory, permitting and licensing processes;
- Identification of training and recruitment resources;
- One-stop environmental permitting.

For More Information Circle No. 548

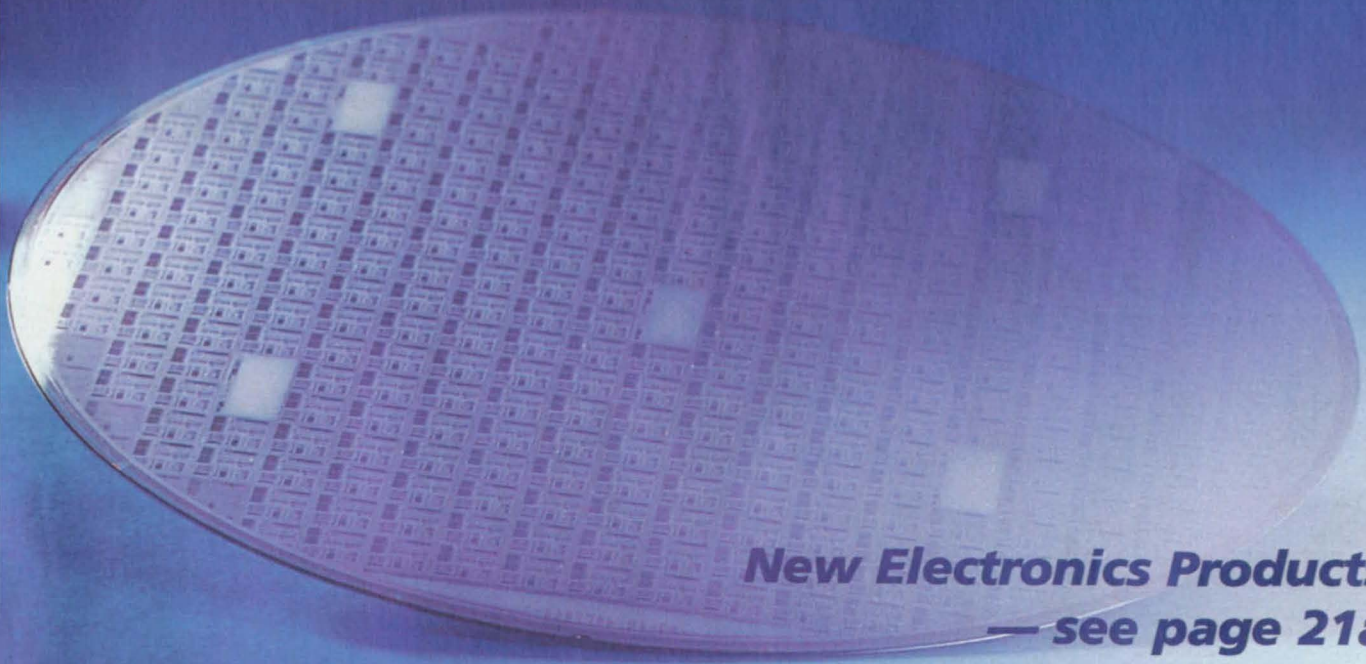
For Information on **Doing Business in Massachusetts**, contact John R. Regan, Executive Director or Nancy Jackson, Dir. of Mfg. Dev.
1-800-5-CAPITAL • **One Ashburton Place, Rm. 2101, Boston, MA 02108 (617) 727-3206** • www.state.ma.us/mobd

Electronics TECH BRIEFS



Software Helps in "Big Bang" Simulation

Advanced Direct Digital Synthesis



New Electronics Products — see page 21a

SONY

The world's most advanced data recorders?

(All DAT and more, SIR.)

Who but Sony could pack speed, range, density, features, and above all, portability, in such small packages. But rugged enough for the toughest field jobs. With multiple power capability: AC, DC, and battery. And, they perform, with individual per channel A/D conversion and 16 bit linear quantization for exceptional data resolution and high dynamic range (80dB or greater). Exceptional data with interchannel phase error of less than 1°. Choose the DAT or even higher capacity SIR series. It's just a matter of how many channels and how much data you require.

DAT PC200Ax Series

- Up to 20 kHz analog bandwidth (100 kHz/PCHB244).
- Up to 3 Mbps digital bit stream recording (mix analog and digital channels on the PCHB244!).
- Multiple channel configurations from 2 to 64 channels.
- A wide range of voltage inputs.
- Up to 6 hours of data storage (4 Gbytes).
- Complete computer integration for remote control.
- Supports Data Transfer from most DAT tapes.

AIT SIR-1000

- 20 kHz analog bandwidth per channel on 16 or 32 channels (up to 256 channels at 5 kHz).
- Digital bit stream recording to 24 Mbps.
- The new Sony AIT (Advanced Intelligent Tape) and drive stores 25 Gbytes.
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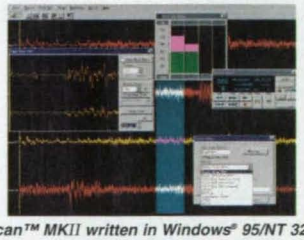

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Electronics TECH BRIEFS

Electronics Tech Briefs Supplement to *NASA Tech Briefs* September 1997 Issue Published by Associated Business Publications

ELECTRONICS TECH BRIEFS

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FEATURE

2a Software Helps Simulate the "Big Bang"

DEPARTMENTS

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On the cover:
Cognex of Natick, MA, has introduced two new image formation systems, one of which, the acuLight II, is shown on the cover. They are designed to address the need for illumination of severely degraded scribes so they can be reliably read by the Cognex acuReader/OCR system.

Software Helps Simulate the "Big Bang"

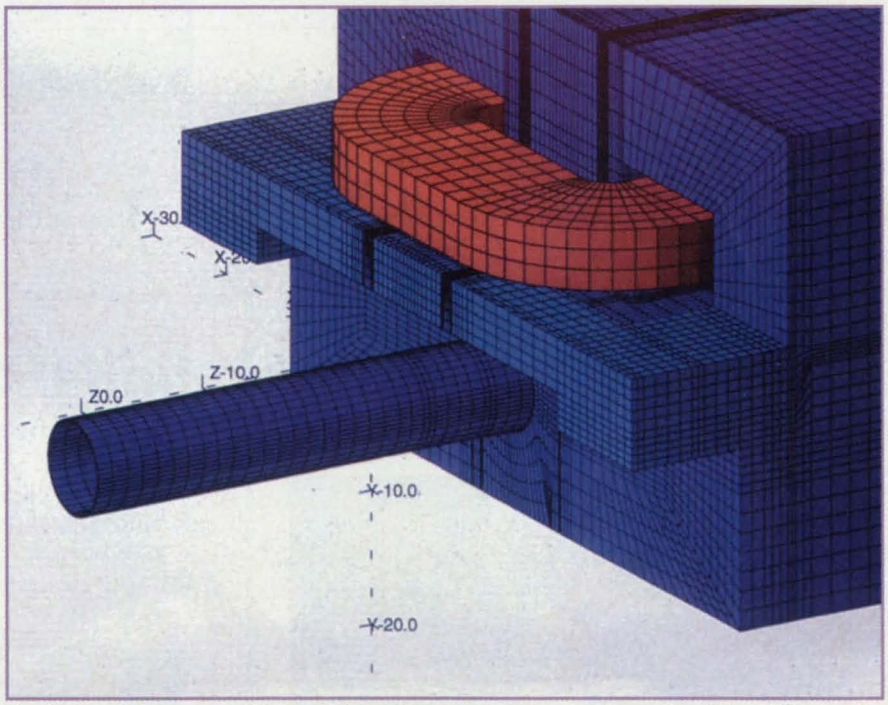
Three-dimensional electromagnetic design simulation software from Vector Fields has helped Brookhaven National Laboratory physicists design a unique magnet that is to play a role in recreating the conditions of the "Big Bang" that formed the universe. The magnet is part of the beam-injection system leading from the Alternating Gradient Synchrotron (AGS) accelerator into the circulating beam of the Relativistic Heavy Ion Collider (RHIC), which is now under construction at Brookhaven. Because the magnet is located precisely at the intersection of the two beams, the strength of its field must transition through four orders of magnitude in only 6 millimeters. With 3D electromagnetic software, Brookhaven scientists evaluated a wide range of alternatives in little time and quickly moved to a feasible design.

The $500-million RHIC will explore matter at temperatures and densities akin to those that existed, scientists theorize, in the original cataclysm called the Big Bang. When the RHIC is completed in 1999, Brookhaven researchers hope to slam groups of metal ions together at energy levels high enough to create a "quark-gluon plasma," a glowing gas-like combination that up to now is believed to have occurred only during the first 10 microseconds of the Big Bang. This should make it possible to test the current theory that protons, neutrons, electrons, and other basic components of matter were formed from the quark-gluon plasma as it cooled.

Cost factors account for the Brookhaven physicists' choice of the nuclei of heavy elements for such collisions. Other accelerators, which are designed for collisions of smaller things such as protons, must be considerably larger. The high cost of the conventional approach was the main reason for the cancellation of the Superconducting Supercollider in Texas several years ago. In fact, the tunnel now being used for the RHIC was originally dug 15 years ago for Isabelle, another big accelerator project that was also cancelled.

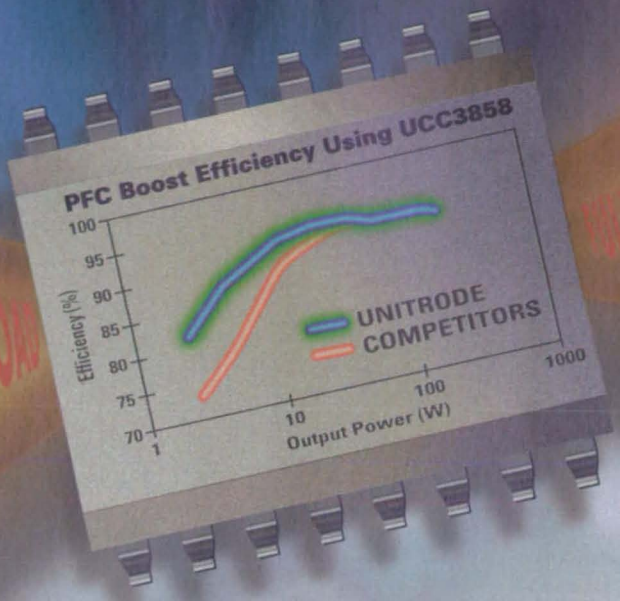
A 500-meter-long line of magnets carries the metal ion beam from the AGS to the RHIC. By far the most critical magnets in the chain are the two that serve as the interface between the injected beam and the circulating beam. It is these that must provide the very strong field to guide the injected beam directly into the path of the circulating beam. Yet each magnet must not disturb the circulating beam, which is only 6 millimeters away from the injected beam at the point where it exits the magnet. Viewed from the top, the injected beam is bent by about 38 mrad, after which it continues on a straight path tangent to the circulating beam. Beam size considerations for both injected and circulating beams dictated that the surface of the bottom pole of the magnet in cross-section view make an angle of 2.57 mrad with the central ray of the circulating beam and 2.24 mrad with the axis of the pipe the beam circulates in. This geometry helps minimize the septum thickness, the minimum distance of the RHIC circulating beam pipe from the lower magnetic pole of the magnet.

Two-dimensional electromagnetic calculations were used to design the magnet's cross-section. The scientists selected OPERA-2D software from Vector Fields of Aurora, IL, to do a two-dimensional analysis of the 4-meter-long magnet for cross-sections well inside the magnet, citing the software's technical depth and breadth and a graphical user interface (GUI) that greatly reduces the time required to complete the analysis. The two-dimensional calculations made it possible to minimize the septum thickness, and therefore to maximize the radius of the circulating beam pipe and still maintain a high magnetic field (~1 Tesla) in the injected beam region, and a low magnetic field ($<10^{-4}$ Tesla) in the circulating beam region.



Simulation of the magnet, rendered with OPERA-TOSCA 3D electromagnetic software, showing the coil, the field clamp, and the beam tube through which the beam of particles is directed.

The 2D software, however, was not able to accurately model the conditions at the exit and entrance of the magnet, which are inherently three-dimensional because of the fringe fields around the exit and entrance holes. For 3D analysis of this region, Brookhaven scientists selected Vector Fields' TOSCA electromagnetic analysis package. This is a well-proven program for the 3D analysis of magnetostatic, electrostatic, and synchronous fields that



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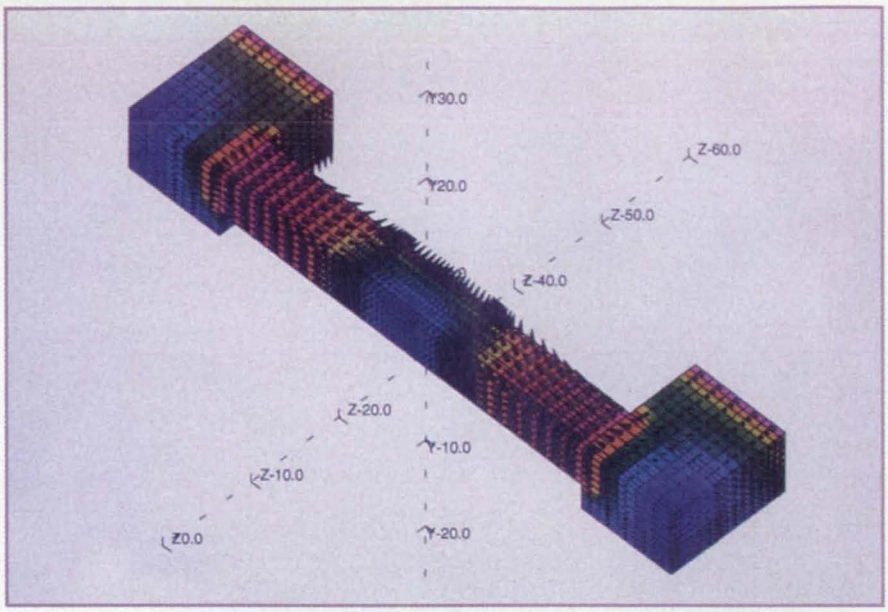
uses state-of-the-art numeric methods. In this application, Brookhaven physicists ran the software on a RS/6000 Model 320 workstation.

Physicists graphically generated a model of the magnet by defining a 2D cross-section through the model and extruding the third dimension. The source currents were specified using the library of coil shapes provided with the program. The analysis provided graphical output including graphs and histograms of the solution and contour plots that showed the magnetic field values superimposed on the surfaces of the model. The key output that was used to guide the design process was a chart that showed the magnetic field in the area of the circulating beam near the exit of the magnet as a function of distance in the direction of beam travel.

The first analysis run showed high field values, in excess of 1000 Gauss, and high gradients in the circulating beam area that were not captured in the 2D analysis. Armed with this information, Brookhaven physicists tried a variety of alternatives in an effort to reduce the field in the critical area. Without the analysis they would have been forced into the expensive and time-consuming task of building and testing prototypes. With the analysis, they were able to change the model to reflect a new concept design in a matter of 30 minutes or so.

The first alternative that the physicists investigated, using the 2D code, was putting more iron into the magnet to reduce the size of the aperture where the beam circulated. Additional analysis iterations showed that this did not improve the problem but actually made it marginally worse. Seeing the effect of this change inspired the physicists to try the opposite approach—increasing the size of the aperture and putting a pipe inside the yoke of the magnet to act as a shield. This approach provided substantial improvements that demonstrated they were moving in the right direction.



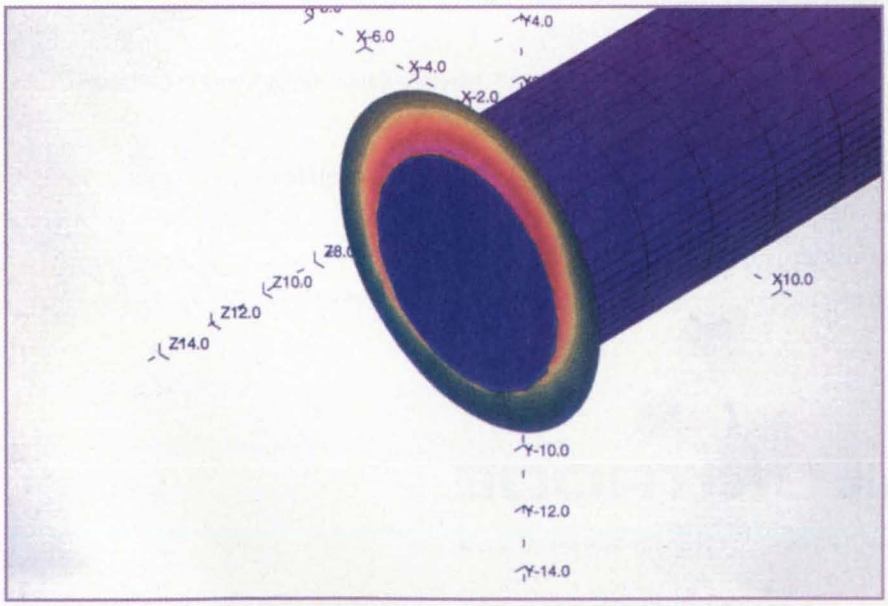
Close-up of the field clamp used to shield the beam tube from the high magnetic field. The cones allow the scientists to view the direction and density of the magnetic field on the surface of the clamp and to facilitate design alterations to achieve optimal shielding.

Further improvements were made using the 3D code by extending the lower pole of the magnet by 7 cm at the entrance and 4 cm at the exit beyond the edge of the top pole piece of the magnet to reduce the fringe field at the circulating-beam region. Field clamps were placed at the entrance and exit of the magnet to further reduce the fringe field. When the analysis results showed a significant improvement, the Brookhaven physicists evaluated several different designs for these clamps. After 14 sequential iterations of changing the design and rerunning the analysis, they accomplished their goal. The final analysis showed a maximum field of only 0.55 Gauss in the circulating-beam region.

The next step was building the magnet and verifying that it worked as the analysis had predicted. The experimental measurements of the corresponding field integral inside the circulating-beam pipe were done with a 4.946-meter-long coil, which was placed inside the circulating-beam pipe with one end of the coil extending well beyond the fringe-field region of the magnet. These measurements showed an actual field value of 0.04 Gauss, even better than predicted by the analysis. It was, of course, very difficult to measure fields this small with the probe used, so the analysis results are well within the range of error of the physical measurements.

The new magnet was proven in operation in January, when Brookhaven scientists shot an intense beam of gold ions through the one-sixth of the ring that had been completed at that point. A pulse containing about 100 million ions zipped through the completed section in about 3 microseconds. The magnet and the rest of the RHIC performed with flying colors. These results clearly show that electromagnetic simulation is a design tool whose time has come.

For more information, contact David Carpenter at Vector Fields, 1700 N. Farnsworth Ave., Aurora, IL 60505; (630) 851-1734; Fax: 630-851-2106; http://www.vectorfields.com.



The corona surrounding the beam tube shows how the high-permeability material absorbs the magnetic field, which allows the particle beam to pass through the cylinder with virtually no disruption. The thickness of the beam tube would need to be increased a thousandfold to afford the same shielding if the field clamp were removed.

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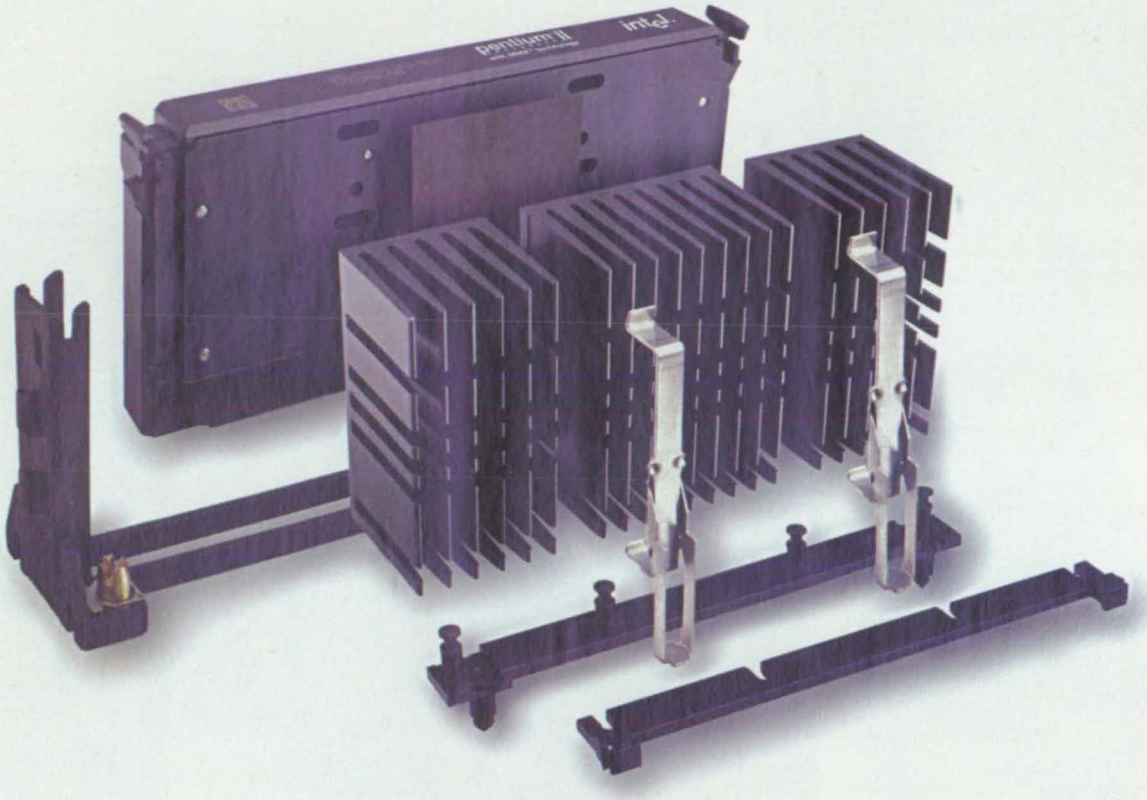

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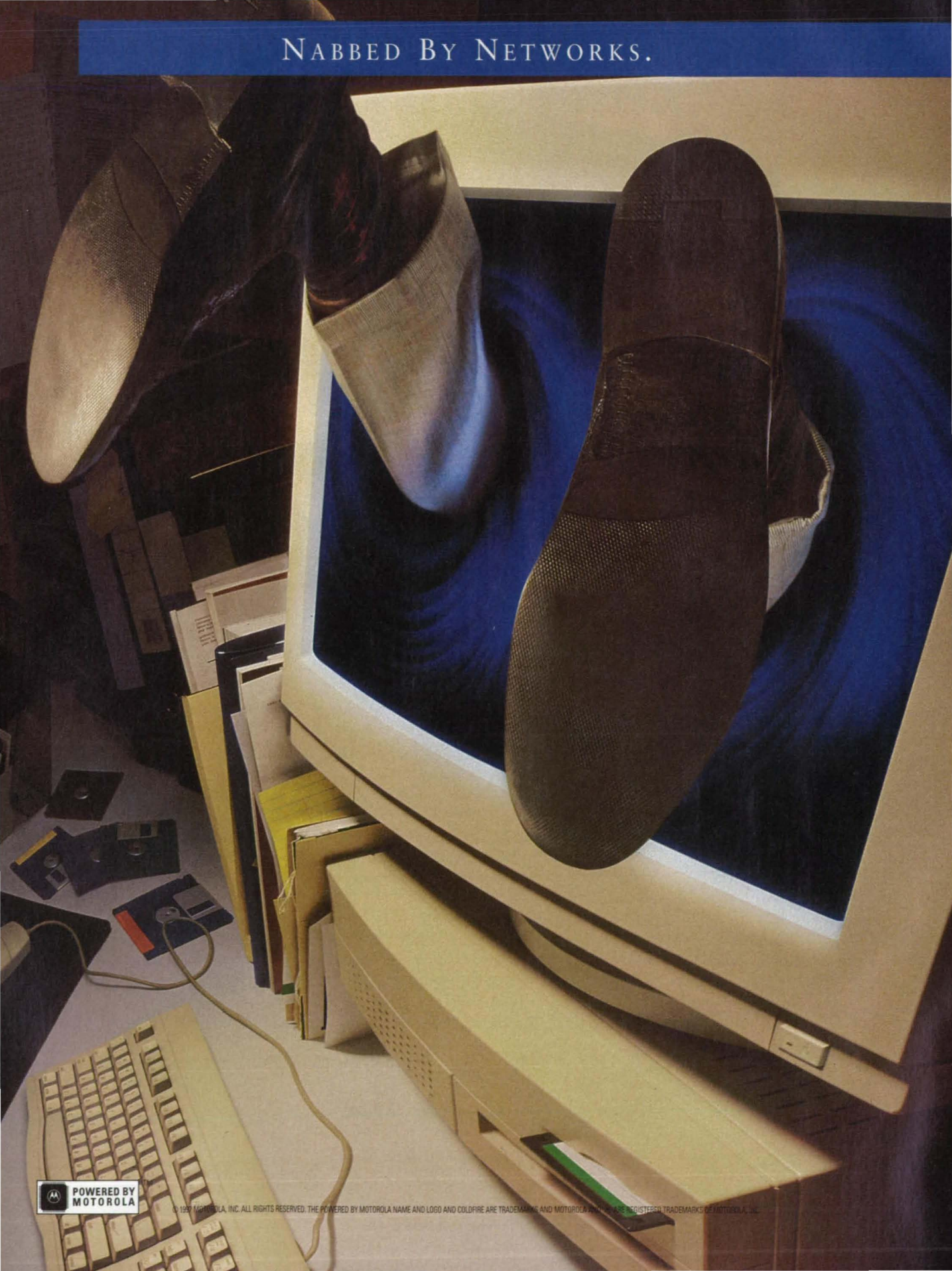

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Direct digital synthesis provides high-fidelity infrared projection capability.

Arnold Engineering Development Center (AEDC), Arnold Air Force Base, Tennessee

AEDC has completed the development of a laser-based direct write scene generation (DWSG) facility, shown in Figure 1, that provides dynamic mission simulation testing for infrared (IR) focal plane arrays (FPAs) and their associated signal processing electronics. The AEDC DWSG focal plane array test capability (FPATC) includes lasers operating at 0.514, 1.06, 5.4, or 10.6 μm, and acousto-optic deflectors (AODs) that modulate the laser beam's position and amplitude.

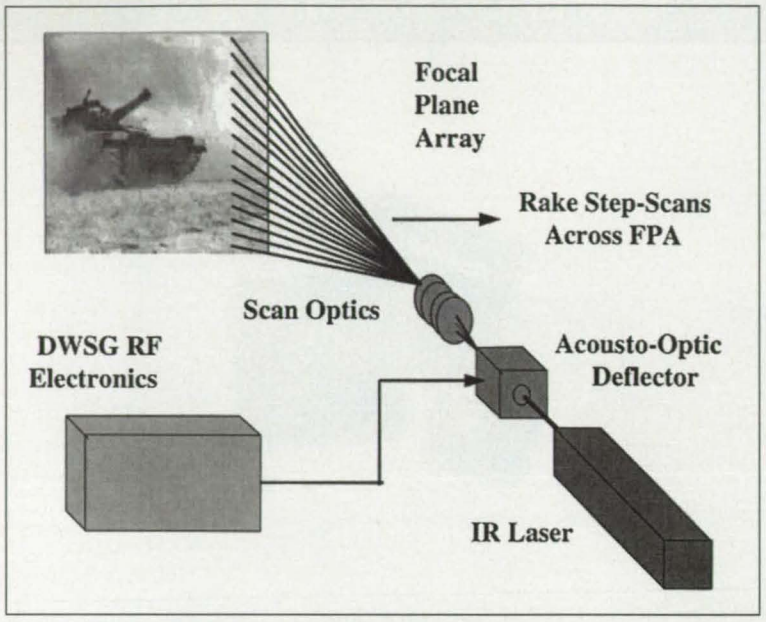

Figure 1. The **Direct Write Scene Generation** concept.

Complex radio frequency (RF) electronics control each AOD by providing multifrequency inputs, which produce a highly accurate and independent multibeam deflection, or "rake," that is swept across the FPA sensor under test. Each RF amplitude input to an AOD translates into an accurate and independent beam intensity in the rake. Issues such as scene fidelity, sensor frame rates, scenario length, and real-time laser beam position adjustments require RF control electronics that employ the use of advanced analog and digital signal-processing techniques and designs, including direct signal synthesis.

Direct digital synthesis (DDS), as implemented in the DWSG electronics, is based upon the integration of three different concepts: numerically controlled oscillation, direct digital attenuation, and high-fidelity frequency conversion.

The numerically controlled oscillator (NCO), shown in Figure 2, is a fundamental building block for any DDS system. The NCO is most easily described by first considering a unit circle with sine-wave values placed at their appropriate phase angles. A pointer is then stepped within the circle at a constant rate. Each value pointed to represents the next instantaneous sine-wave value with generated frequency F_g, where F_g is the rate that the pointer moves around the circle. The value F_g is derived by knowing the pointer stepping rate, and the size of each step, which can be expressed as a change in phase angle, $d\phi$. The pointer's stepping rate is the oscillator's sampling rate, F_s. Using the unit circle analogy, the generated frequency can be expressed as

$$F_g = F_s \times d\phi.$$

The analogy translates to hardware by simply building a counter with variable step size and sampling clock. The phase accumulator in Figure 2 shows a programmable step size ($d\phi$) input sampling clock, and feedback summing loop to produce discrete digital phase angles at its output. The digital phase angles are applied to read-only memory (ROM) address lines that convert the phase angles to sine-wave codes that are ready for input to a digital-to-analog (D/A) converter. Since F_s is generally constant, F_g is set by the programmable $d\phi$ register. If N represents the total register bits, and n represents the current count in the register, then $d\phi$ is expressed as

$$d\phi = n/2^N.$$

There are three major advantages for using NCO technology in the DWSG electronics design. First, it achieves very good frequency stability, since the oscil-

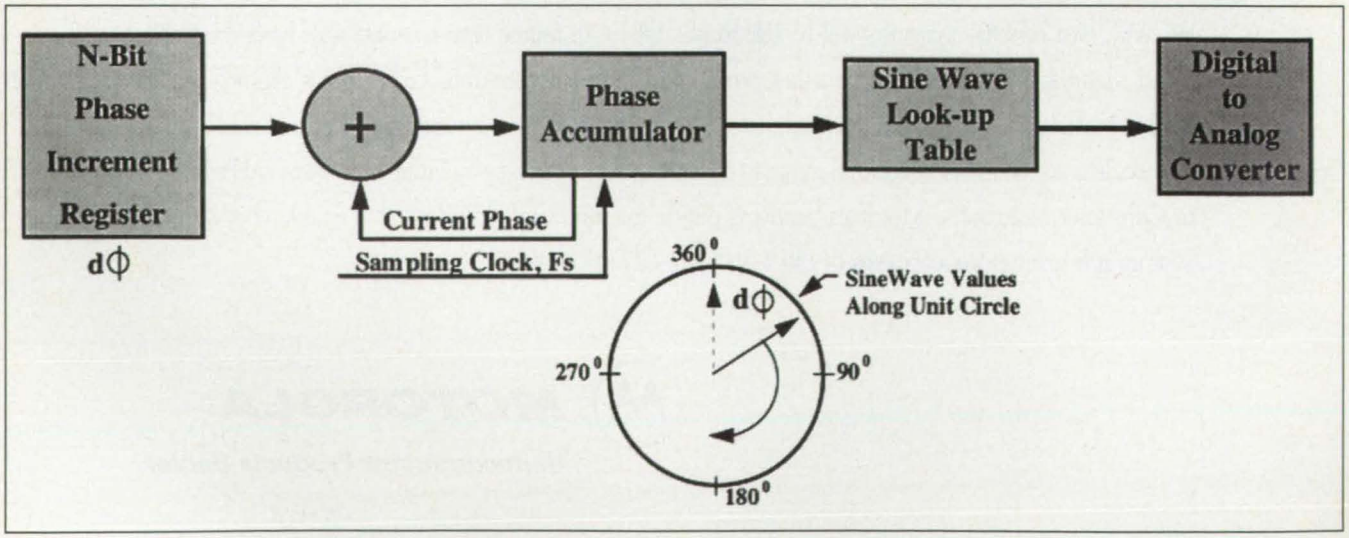

Figure 2. **Numerically Controlled Oscillator** concept.

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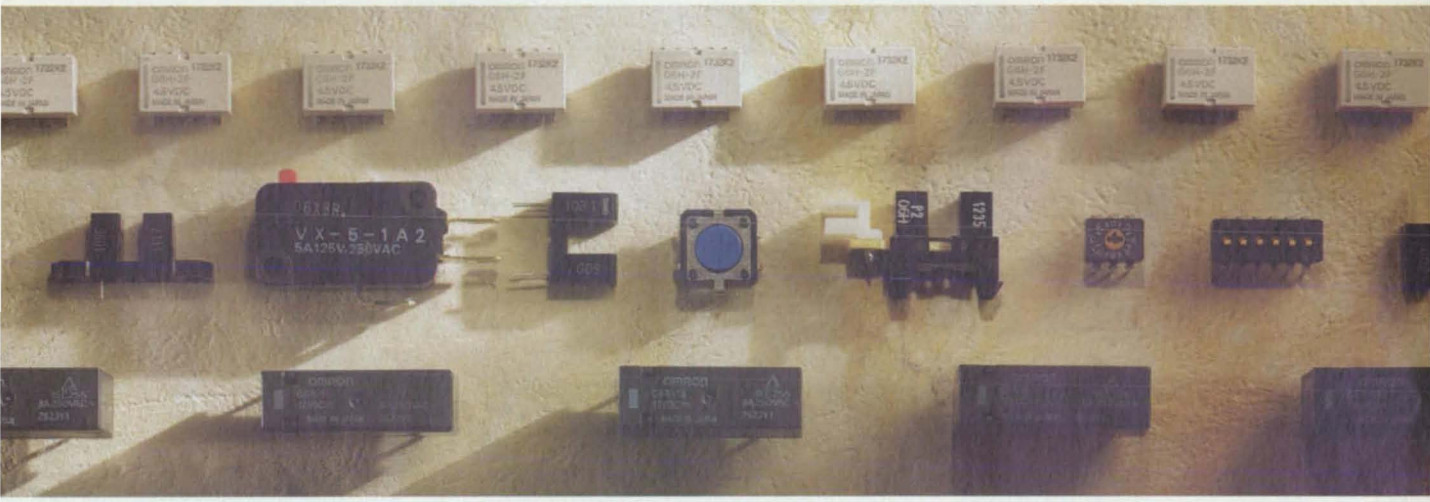

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lator has no temperature-dependent components that tend to drift over time. As a result, the NCO is as stable as the F_s input clock. Second, it produces very fast frequency switching times, on the order of 50 ns, since the NCO feedback loop is updated every clock cycle. This is impossible to achieve with the large divider rations and loop settling times that are associated with conventional voltage-controlled oscillator phase-locked-loop technology. Third, it achieves very fine frequency resolution, since the phase register can have a large number of bits. For example, with a 32-bit dϕ register and 25-MHz sampling clock, the output frequency can be controlled within 0.005-Hz resolution.

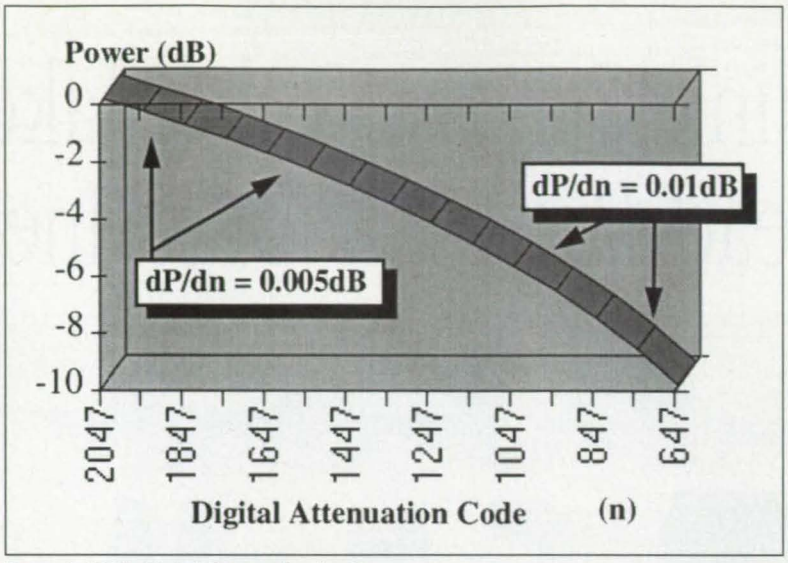

Figure 3. **12-Bit Digital Attenuation** in dB.

An important part of the DWSG requirement is the ability to control RF power (beam intensity) over a 40-dB range with 0.01-dB resolution. In prototype, this had been accomplished with a combination of digitally switched RF attenuators, and pulse-width amplitude modulation (PWAM) during the dwell period. The added complexity of PWAM circuitry combined with the added cost of developing a 12-bit digitally switched RF attenuator made it desirable to look for an alternate FPATC design methodology. As a result, direct digital attenuation (DDA) was pursued as an alternative approach.

Direct digital attenuation takes the NCO sine-wave code, and digitally multiplies it with a scaling code before clocking the data value into the D/A converter. As a result, the DDS frequency and amplitude can be digitally controlled. An equation that described DDS output power as a function of attenuation code was needed to establish the number of bits required for 0.01-dB resolution. If n represents the attenuation code, and N represents the total of bits in the attenuation register, then the power output P can be expressed in dB as

$$P = 10(\mathrm{Log}(n^2)-\mathrm{Log}(2^{2(-1)})).$$

Further, the resolution, or power step size, at any given attenuation code can be found by taking the derivative of P with respect to n, giving

$$dP/dn=20(\mathrm{Log}(e)/n).$$

Figure 3 shows power attenuation versus attenuation code, assuming a 12-bit DDS using 2's complement D/A codes. Although output power is not linear with attenuation code, the first 1400 codes span a dynamic range of 10 dB with 0.01-dB resolution. This allows the use of coarse RF attenuators to provide 5 or 10-dB steps that will span the dynamic range required, and the use of DDA to fill in the gaps with high-resolution steps. The combination of DDA with coarse RF attenuation is less costly, since coarse RF attenuators and digital multipliers are readily available.

The concept of high-fidelity frequency conversion is critical, since DDS hardware that operates in the 15 to 125-MHz bandwidth is expensive, and digital attenuation becomes more difficult as the DDS sampling frequency increases. Also, the size of DDS modules in the required 15-125-MHz bandwidth would make it difficult to integrate 512 channels into one system. Consequently, an image of the desired signal that has the required fidelity is created in a 6-to-10-MHz band, and then frequency-converted into the AOD bandwidth without loss of fidelity. This approach capitalizes on DDS technology that is less costly to implement because of the lower operating bandwidth.

Currently, direct digital synthesis has been successfully implemented in the DWSG focal plane array IR simulation test facilities at the Arnold Engineering Development Center.

This work was done by the Air Force's **Arnold Engineering Development Center**. *Inquiries concerning the rights for the commercial use of this system should be addressed to Capt. Frank Fairchild, AEDC, Arnold AFB, TN 37389-9011; (615) 454-3721; or Bob Fugerer, AEDC, Arnold AFB, TN 37389-6400; (615) 454-6889.*

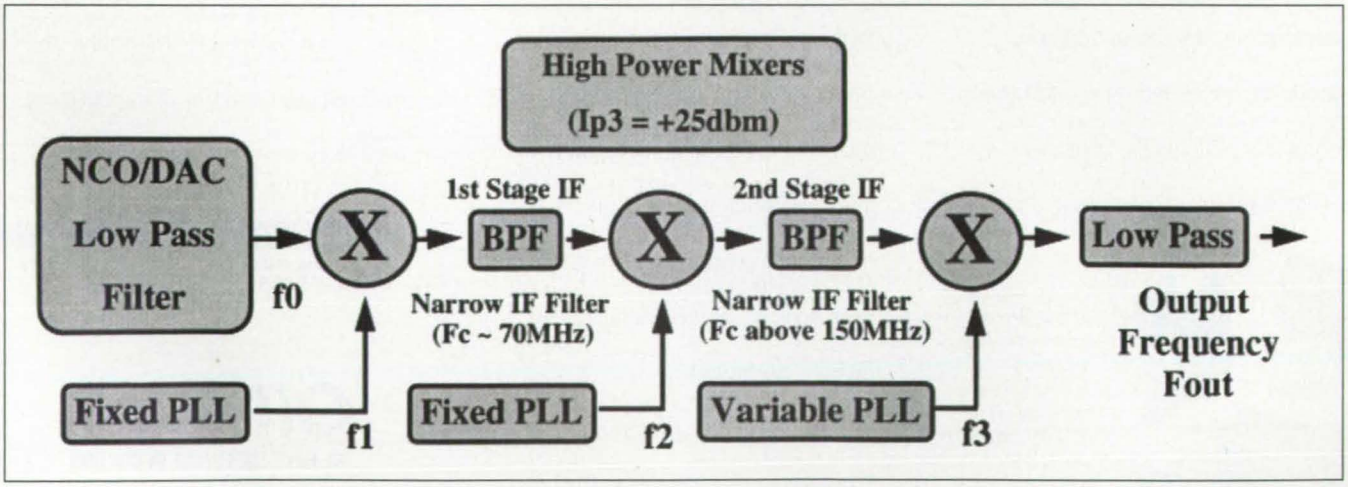

Figure 4. **High-Fidelity Frequency Conversion** concept.

High-Power Photodiodes for Microwave Fiber-Optic Links

High-saturation-level PIN photodiodes are embedded in waveguide structures.

NASA's Jet Propulsion Laboratory, Pasadena, California

Optical waveguide geometry photodetectors with increased optical saturation powers are being developed for use in detecting analog signals that are transmitted through optical fibers with laser light that is modulated at microwave frequencies. Transmission of microwave signals through optical fibers offers tremendous improvements in both flexibility and loss due to the unique properties of optical fibers. However, significant losses can occur during the electrical-to-optical and optical-to-electrical conversions required at each end of the fiber-optic link. These conversion losses can be overcome through the use of a high-power laser and an external modulator at the transmitter and a high-speed, high-saturation power photodetector at the receiver. At present, the performance of these links is limited by the saturation power of the high-speed photodetectors; saturation produces a nonlinear electrical output at the receiver, which degrades the fidelity of the link.

To increase the optical saturation level of the detectors while preserving high electrical frequency response, the geometry and material layer compositions need to be chosen carefully. First, the optical waveguide geometry is selected, as it provides the ability to achieve both high-speed operation and good optical-to-electrical conversion efficiency (see Figure 1). This results from the ability to use a thin layer of absorbing material, which maximizes the speed of the detector by minimizing the transit time for the photogenerated electrical signals (electrons with negative charge and holes with positive charge). Ideally, each absorbed photon creates a single electron-hole pair that escapes the detector due to the applied electric field. The conversion efficiency of the detector is maintained through the use of the optical waveguide geometry, which confines the incident optical signal within the detector and forces a continual interaction of the light with the thin absorbing layer as the light travels down the length of the detector. The interaction length required for complete absorption of the light determines the length of the waveguide photodetector. Next, while the material layer composition of the positive/intrinsic/negative (PIN) detector is chosen to create the optical waveguide, at the same time this creates energy steps or barriers for the photogenerated electrons and holes to overcome in their transit out of the absorbing layer and out to the electrical terminals of the detector.

During operation, the device is reverse biased such that the applied electric field pulls the holes out of the positive side of the detector and the electrons out of the negative side of the detector. Due to the different effective masses of the electrons and holes, an asymmetric material design has been utilized to minimize these barriers for both the electrons and holes while maintaining an effective optical waveguide, and a comparison has been made to a standard symmetric material design. Overall dimensions of the waveguide detector have been chosen to limit parasitic resistance-capacitance

and transit-time effects for operation beyond 40 GHz.

The standard symmetric waveguide photodiode contains InP and InGaAsP on both the p-doped and n-doped sides of the intrinsic InGaAs absorbing layer, with all of the material layers lattice matched to the semi-insulating InP substrate. The asymmetric waveguide photodetector replaces the InP and InGaAsP on the p-doped side with lattice matched InAlAs and InAlGaAs material layers that provide much smaller energy barriers for the photogenerated holes, while still maintaining the proper optical waveguiding characteristics.

Prototypes of both the symmetric and asymmetric devices have been made and tested, with both showing excellent electrical and dark-current properties. Uniform responsivity was obtained from both devices for applied biases between +0.25 and –5 V. Responsivity at small positive voltages indicates a significant built-in field due to the p and n regions and implies that these devices may be operated at relatively low bias levels. A significant improvement in the efficiency and linearity of the asymmetric design was observed (see Figure 2). A linear variation of photocurrent with incident optical power was observed for photocurrents over 8 mA for the asymmetric design. At present, this measurement is limited by the output power of the laser.

This work was done by Timothy A. Vang, Lawrence J. Davis IV, and Sam Keo of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Electronic Components and Circuits category,* ***or circle no. 132*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

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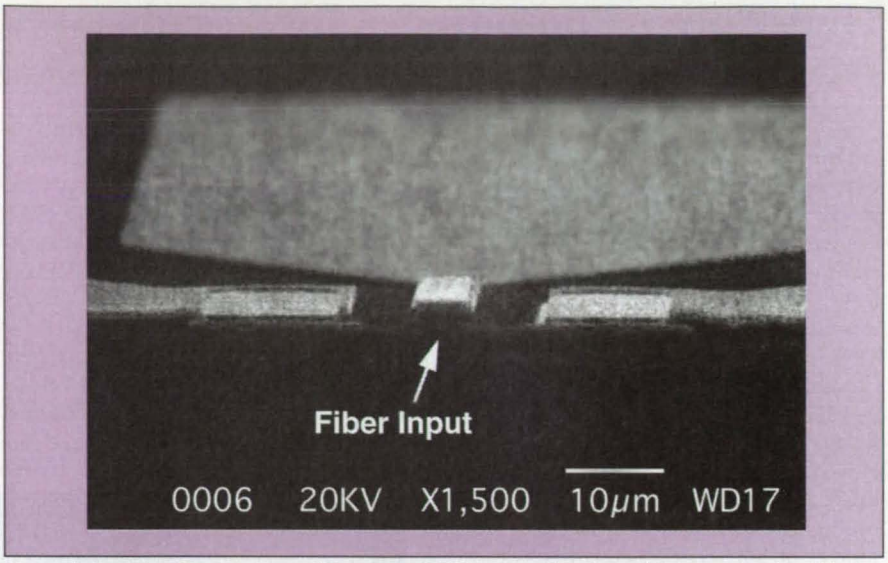

Figure 1. **Scanning Electron-Beam Microscope (SEM)** image of a cleaved-facet waveguide PIN photodetector is shown mounted for testing.

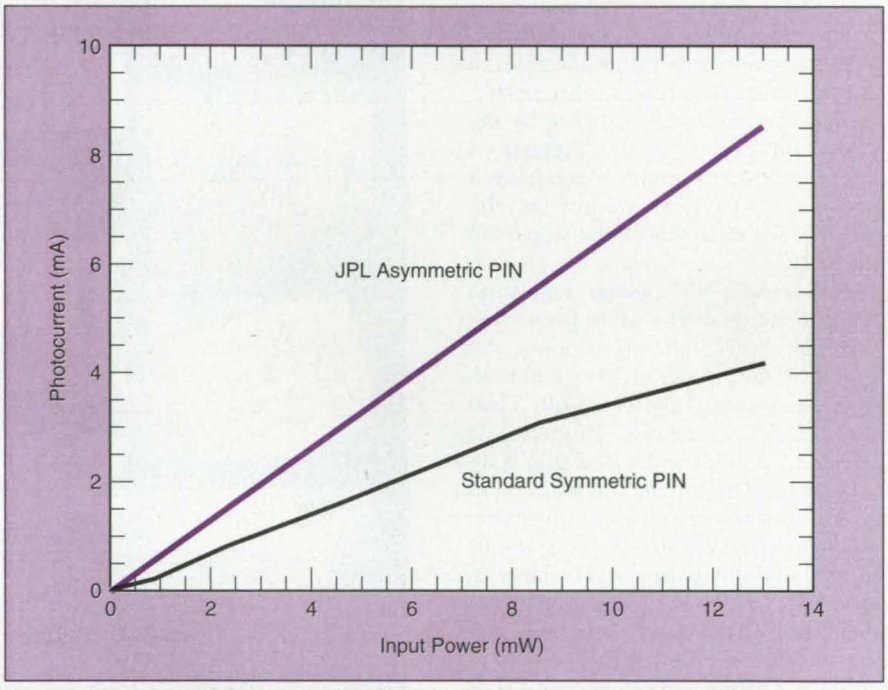

Figure 2. **Comparison of the Reponsivity** of standard and asymmetric waveguide PINs was measured at a bias of –3 V.

Disposable Elastomeric Ozone Detector

Adjustable sensitivity allows ozone measurements over a wide range of conditions.

Naval Research Laboratory, Washington, D.C.

The elastomeric ozone detector is a sensitive, inexpensive means of measuring the concentration of ozone (O_3) in ambient or other conditions. The sensing material is a low-cost, initially transparent elastomeric film.

The device functions through formation of micron-sized cracks on the surface of the film, which reduces optical clarity. The amount of light scattered from the cracks increases as the concentration and depth of the cracks increase over time. Hence, an initially clear sample becomes more opaque as ozone-stress-cracking proceeds. The concentration of ozone can thus be readily determined from the light transmittance of the film.

The sensitivity of the sample to ozone attack can vary by at least two orders of magnitude, depending on the strain of the sample. An unstrained film is impervious to ozone-stress-cracking; unstrained samples can be stored indefinitely without loss of properties. Once under tension, however, crack growth due to ozone proceeds rapidly. Samples that have experienced ozone-stress-cracking can be stored without further change of the relative transmittance by

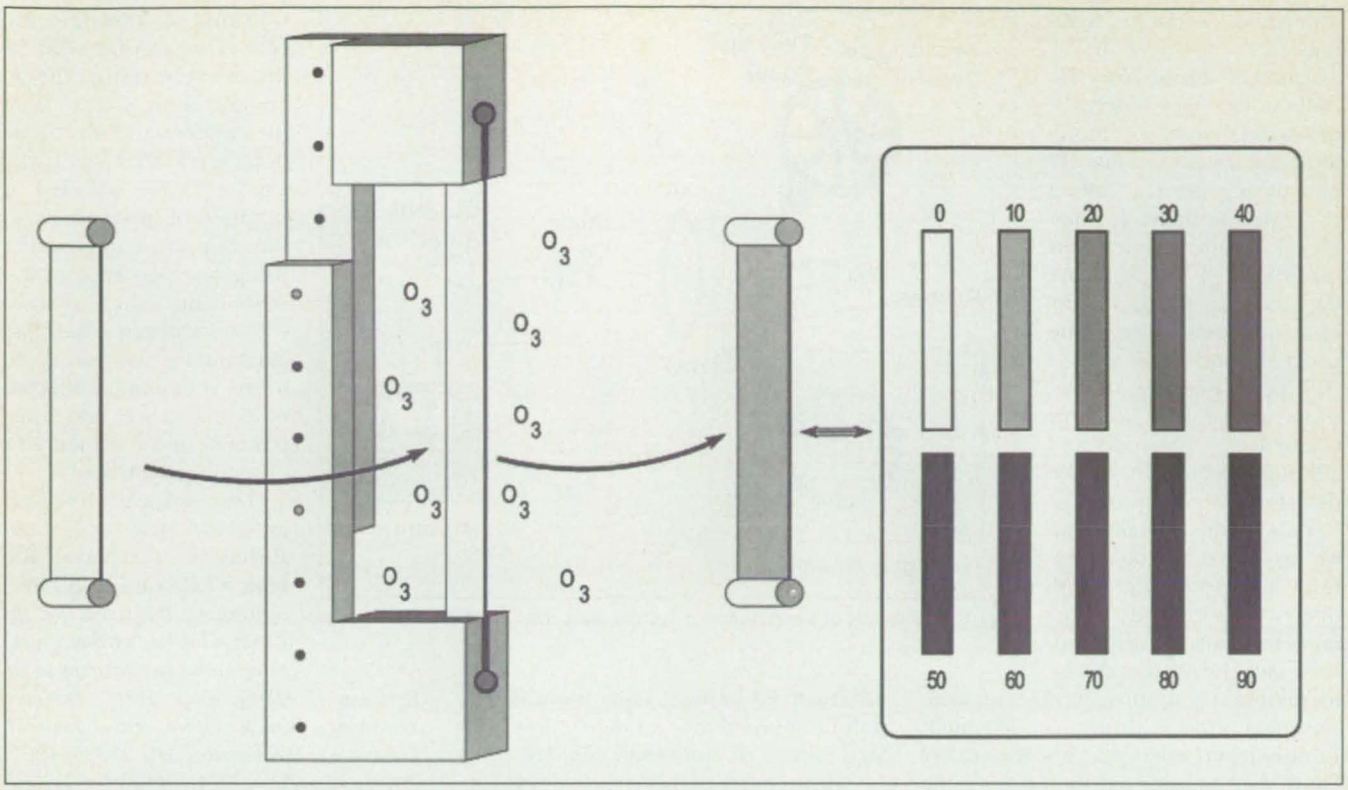

Figure 1. Use of the **Elastomeric Ozone Detector Film** as a disposable "litmus paper" detector.

removing the strain. This allows for archiving.

Figures 1 and 2 illustrate two implementations of this technology. In Figure 1, the film is used as a simple disposable "litmus-paper"-type detector. An initially clear, unstrained sample is loaded into an adjustable stretching frame. Exposure to the ozone-containing atmosphere for a given length of time (*e.g.*, a few minutes) causes the surface of the film to become "frosty," a consequence of micron-sized cracks present on the surface. After the test period is over, the test operator compares the exposed sample to a standard, allowing determination of the loss of light transmittance. This quantity is directly translatable into ozone concentration via a calibration table. The table accounts for differences in sample strain and exposure time, factors that can be adjusted to optimize sensitivity and accuracy for a given situation.

Of course, far more precise instruments than this "litmus-paper" device can be constructed. Figure 2 depicts an automated system, whereby the rubber film is continuously passed from one roller to another. Only the rubber between the rollers is in tension, and thus only there does the film experience an optical density change in proportion to ozone concentration. The information can be made instantaneously available electronically through use of a low-cost photodiode. Alternately, the rewound film can function as an archival storage medium.

Both implementations of the detector are fully capable of measuring ambient atmospheric ozone levels down to 5 ppb. The "litmus-paper" kit is capable of providing "go-no go" measurements, while the battery-powered instrument will give

repeatable, accurate readings.

Ambient ozone concentrations can vary widely. In the winter, outdoor ozone levels are usually less than 40 ppb during the day, falling to 15 ppb at night. In summer concentrations often reach 120 ppb during a hazy day. Indoors, in the vicinity of certain appliances, ozone concentrations can exceed 500 ppb. Because of the wide range of ambient ozone levels, the wide and adjustable sensitivity of the detector is very important.

This tunability allows a variety of ozone concentration measurements to be made. If short-term "spike" measurements are required, this can be achieved by increasing the strain such that the measurement time is short (ca., seconds). Longer-term averages, on the other hand, can be achieved by reducing the sample strain. For example, at a given ozone concentration, the time required to reach 50 percent light transmission can be adjusted over a range of less than one minute to more than one day.

The accuracy of this technology is limited only by the accuracy of equipment that measures the relative light intensity transmitted through the film. This accuracy can be increased by using calibrated light sources (for example, a laser) and electronic detectors. The sensitivity can be further adjusted by variation of the modulus of the elastomeric film, and by using several samples, and measuring the relative transmittance in series. The elastomer's response to ozone is minimally affected by temperature, and independent of the presence of other air pollutants.

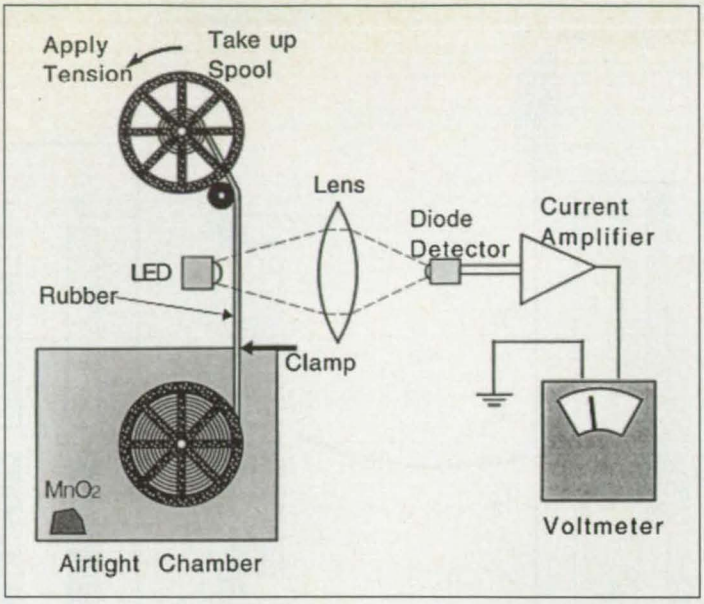

Figure 2. Schematic of the **Automated System** using the film on a rubber roller.

This work was carried out by P.H. Mott and C.M. Roland at the **Naval Research Laboratory**. *Inquiries concerning the rights for the commercial use of this invention should be addressed to Dr. Richard H. Rein, code 1004, Director, Technology Transfer Office, Naval Research Laboratory, Washington, DC 20375; (202) 767-7230; FAX (202) 404-7920; E-mail: rein@utopia.nrl.navy.mil*

Circuit Maintains Centering of a Laser Frequency Scan

Drift in the nominally steady component of frequency offset is corrected automatically.

NASA's Jet Propulsion Laboratory, Pasadena, California

An electronic circuit maintains centering of a ±3-GHz frequency scan of a local-oscillator laser in a Doppler lidar system. The need for such a circuit arises as follows: In the Doppler lidar system, the frequency scan of the local-oscillator laser involves the generation of (1) a sinusoidally varying tuning voltage superimposed on (2) a dc tuning voltage. The sum tuning voltage is applied to a piezoelectric transducer that adjusts the length of the local-oscillator-laser cavity and thereby changes the local-oscillator frequency. The frequency scan is required to be symmetrical about the frequency of a master-oscillator laser, but in the absence of corrective action, the frequency scan becomes asymmetrical because the central frequency of the scan drifts gradually (see Figure 1). The overall function of the present circuit, described in more detail below, is to periodically adjust the dc tuning voltage to keep the frequency scan centered at the master-oscillator frequency.

The circuit (see Figure 2) includes a photomixer detector, on which small samples of the master- and local-oscillator laser beams are incident. The mixer output consists primarily of a beat note

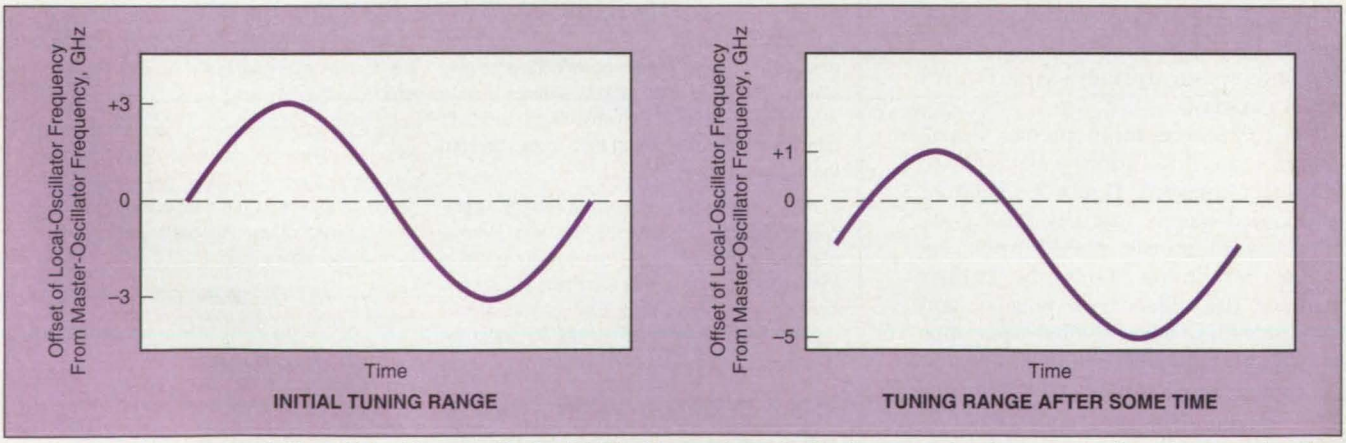

Figure 1. The **Frequency Scan is Sinusoidal**, with an amplitude of 3 GHz. The scan is required to be centered at the master-oscillator frequency, but thermal, aging, and other effects can cause the central frequency to drift.

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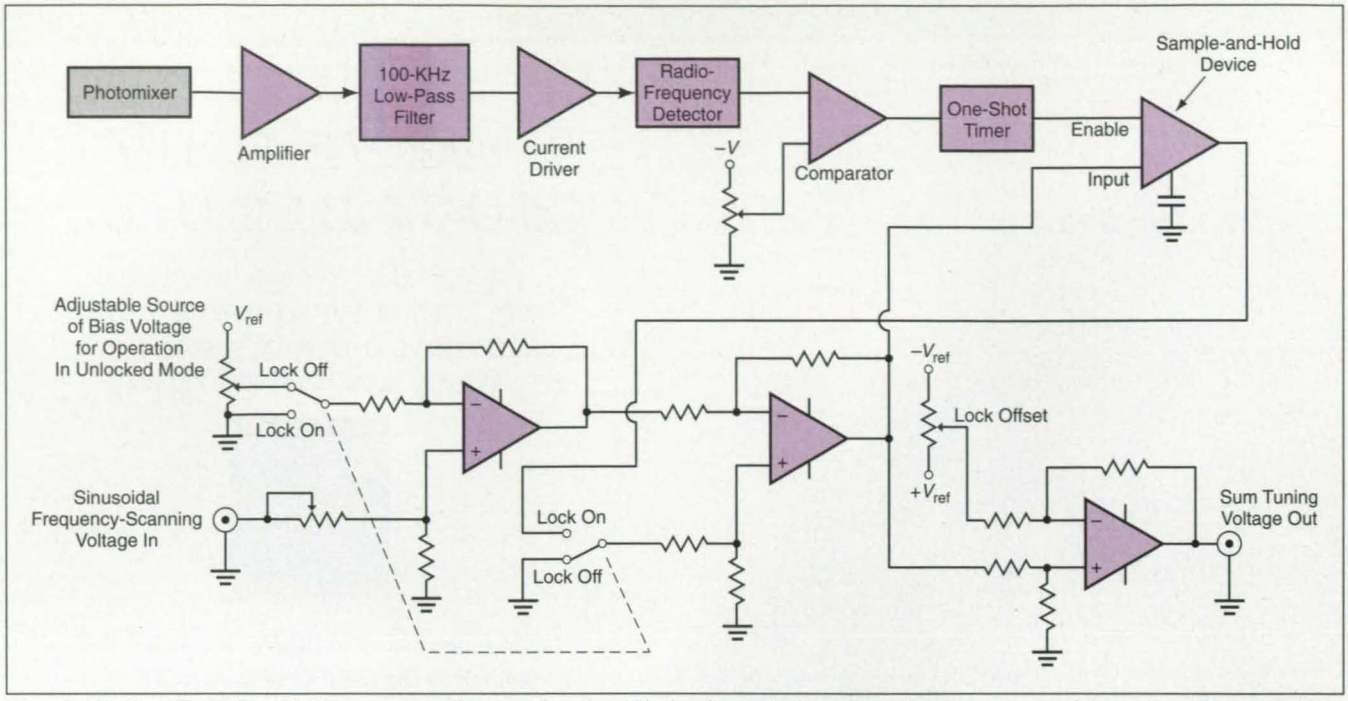

Figure 2. This **Simplified Schematic Diagram** shows the major functional blocks of a circuit that adjusts the dc component of the tuning voltage to lock the central local-oscillator frequency to the master-oscillator frequency. Optionally, the lock frequency can be offset somewhat from the master-oscillator frequency. The circuit can also optionally be switched to operate in a non-frequency-locking mode.

between the local- and master-oscillator signals. The beat note is amplified by a factor of 10, then sent through a low-pass filter with a cutoff frequency of 100 kHz. The net effect of the amplification and low-pass filtering is to generate a burst signal at frequencies < 100 kHz whenever the beat note passes through zero frequency; that is, whenever the local-oscillator frequency passes through the master-oscillator frequency.

The burst signal is fed to a radio-frequency detector, which converts the burst into a voltage spike. A comparator converts the voltage spike into a clean pulse, which triggers a one-shot timer. The one-shot timer engages a sample-and-hold device, which samples the instantaneous sum tuning voltage. Because the timing pulse is initiated whenever the local-oscillator frequency crosses the master-oscillator frequency, the voltage held by the sample-and-hold device is the tuning voltage that causes the local-oscillator frequency to equal the master-oscillator frequency. The dc component of the tuning voltage is reset to this held voltage. Thus, twice during each frequency scan (at the two frequency-crossover points), the dc component of the tuning voltage is adjusted to reset the central frequency of the scan to the master-oscillator frequency.

This work was done by Carlos Esproles of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category,* ***or circle no. 133*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*
NPO-20040

Miniature Inside-Out EPR Spectrometers

Large samples could be probed from surface or bore-hole locations.

NASA's Jet Propulsion Laboratory, Pasadena, California

Miniature electron-paramagnetic-resonance (EPR) spectrometers have been proposed for use in field analysis of soil, rocks, and ice. These instruments would incorporate some of the features of the ones described in "Portable Wide-Band EPR Spectrometers" (NPO-19532), *NASA Tech Briefs*, Vol. 21, No. 3 (March 1997), page 56. The unique feature of the proposed EPR spectrometers would be "inside-out" sampling-head configurations that would cause sampling dc magnetic and microwave-frequency fields to reach out to small regions outside the sampling heads.

To operate a conventional laboratory EPR spectrometer, it is necessary to place the sample to be analyzed in a microwave cavity with a small sample volume (typically, no more than 2 cm^3). However, preparation and insertion of small samples can be difficult under field conditions. The proposed instruments would make it unnecessary to prepare small samples; instead, one could utilize the external sampling fields to probe large rocks, soil banks, and ice from surface or bore-hole locations.

The "inside-out" designs of the sampling heads of the proposed EPR spectrometers would be derived from similar designs of sampling heads of some oil-well logging nuclear-magnetic-resonance (NMR) spectrometers. Each sampling head would comprise permanent magnets and a microwave dielectric or tunable microstrip resonator. Figure 1 illustrates a typical unit for surface sampling; in this case, it would be possible to incorporate the sampling head and the associated electronic circuitry into one compact package. Figure 2 illustrates a typical unit for bore-hole sampling; in this case, the requirement for compactness to fit in the bore hole would dictate that some of the electronic circuitry be housed aboveground.

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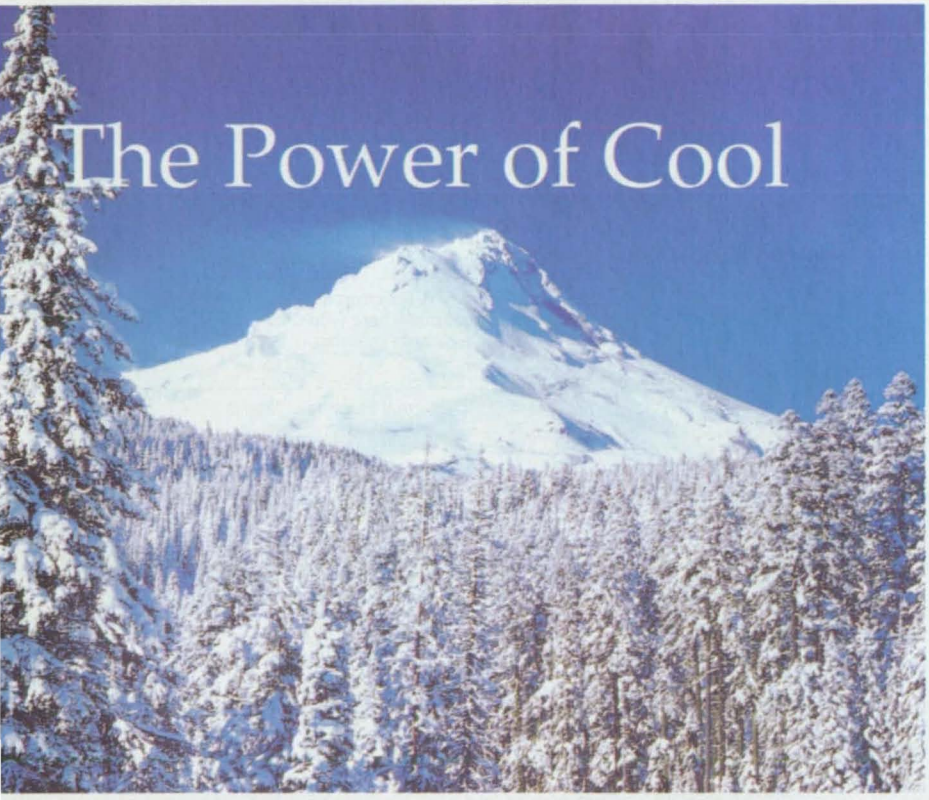

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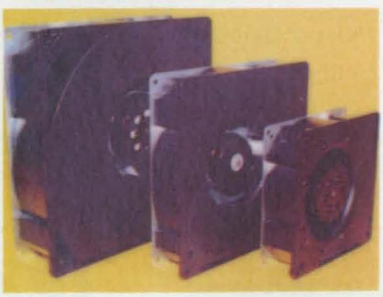

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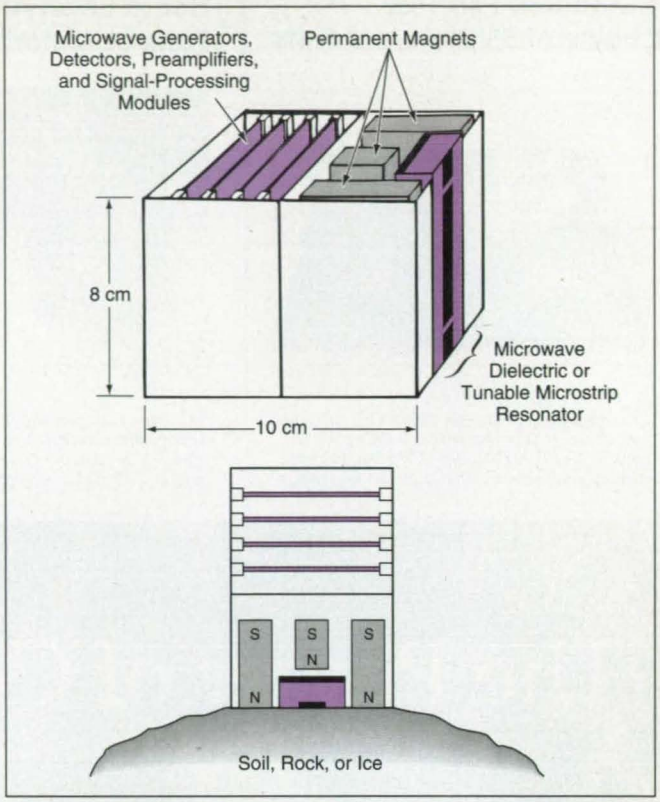

Figure 1. This **Miniature EPR Spectrometer** would simply be placed on the rock, soil, or ice to be analyzed; there would be no need to break off a small sample and insert it in a sample chamber.

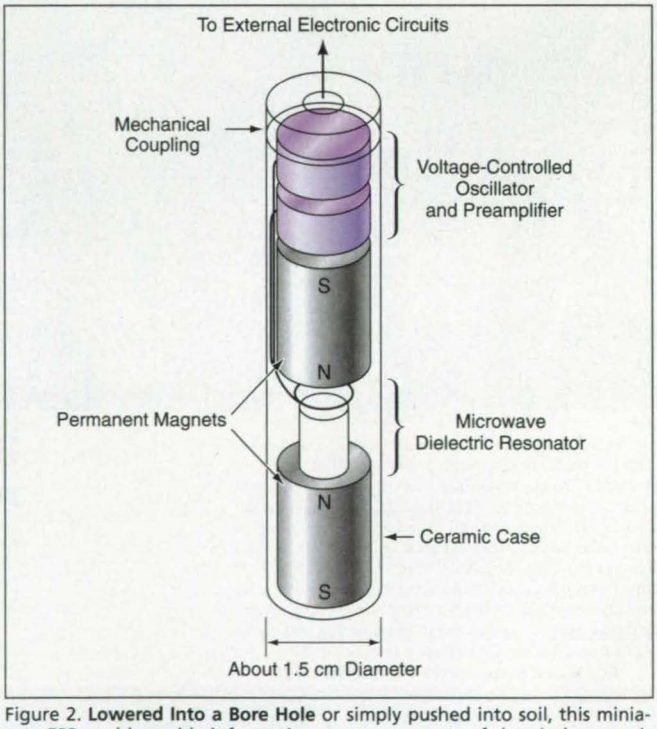

Figure 2. **Lowered Into a Bore Hole** or simply pushed into soil, this miniature EPR could provide information on some aspects of chemical composition (e.g., concentrations of paramagnetic transition metals) as a function of depth.

This work was done by Soon Sam Kim and Narayan R. Mysoor of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 134*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

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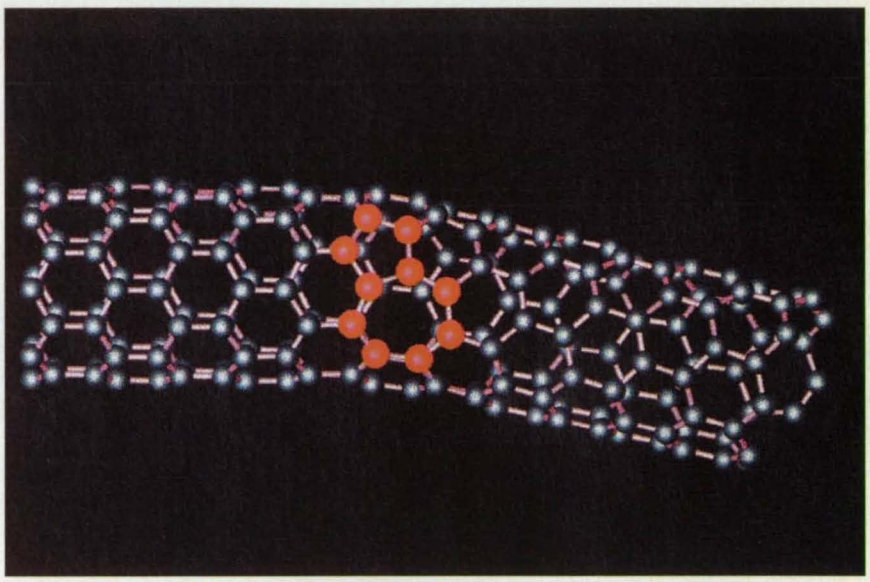
Carbon Nanotubes Form Metal/Semiconductor Junctions

Pair defects enable the creation of nanometer-scale diodes.

Lawrence Berkeley National Laboratory, Berkeley, California

Berkeley Laboratory researchers have constructed carbon nanotubes containing metal/semiconductor or semiconductor/semiconductor junctions that may be used to form electronic devices that are 1-2 nanometers in each dimension. Nanoscale devices envisioned include Schottky barriers, quantum wells, and transistors 10,000 times smaller in area than present commercial silicon devices.

Envisioned applications include extremely small-scale circuit elements, sensors for strain and other properties, small, robust, and sensitive. In stiffness, the Young's modulus of individual carbon nanotubes exceeds that of the strongest carbon fiber. They are structurally stable at high temperatures, and the resistivity of certain symmetric junctions is sensitive to mechanical deformation.



A **Semiconducting/Metal Junction** (red balls) formed from two carbon nanotubes.

The researchers discovered a topological solution that matches tubes with different electronic structures, making the carbon nanotube devices possible. Carbon nanotubes are synthesized to contain pentagon-heptagon pair defects in their normal hexagonal structure. The defects change the helicity of the nanotube and alter its electronic structure. In addition to forming all-carbon heterojunctions, the tubes can be doped with boron or nitrogen.

The devices were synthesized in a proprietary plasma arc discharge chamber. Their structure was characterized with transmission electron microscopy.

The devices are mechanically strong, and high-temperature electronic devices. Development aims include micron-long nanotubes with multiple metal/semiconductor and semiconductor/semiconductor junctions produced in the lab.

This work was done at **Ernest Orlando Lawrence Berkeley National Laboratory**. *Patents are pending, and licensing and/or joint development is available. For further information contact Bruce Davies, Lawrence Berkeley National Laboratory, Technology Transfer Dept., 1 Cyclotron Rd., MS 90-1070, Berkeley, CA 94720; (510) 486-6467; FAX: (510) 486-6457; E-mail: ttd@lbl.gov; http://www.lbl.gov/Tech-Transfer; http://Tiger/Berkeley.edu/vin/index.*

NEW PRODUCTS

Product of the Month

Software/Platform for Semiconductor Inspection

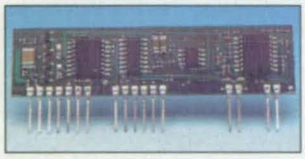
Cognex, Natick, MA, introduces the 8000 Series™, a new machine vision platform that incorporates its new PatMax™ software and plugs directly into the PCI bus of standard Pentium MMX™ computers. The series includes a range of products from the low-cost 8100 to the 8400, which incorporates a digital signal processor that enables operation up to 10 times faster than current Cognex products. The company also says that PatMax-equipped systems will locate and precisely align the new 300-mm generation of wafers before probing, metrology, inspection, and bonding. And because PatMax can accurately locate wafer and die patterns despite variances introduced by chemical mechanical processing and other processing steps, it will help manufacturers improve their wafer alignment yield. It will also improve yield by increasing speed and accuracy on production machines, including surface-mount-device pick and place equipment.

For More Information Circle No. 751

Miniature High-Voltage DC-to-DC Converters

EMCO High Voltage Co., Sutter Creek, CA, offers three new DC-to-high-voltage-DC converters supplying 0-8 kV, 0-10 kV, and 0-12 kV in a 2.5 × 1.5 × 0.85-in. module. Output power is 2 W and ripple less than 1.5 percent. A quasi-sine-wave oscillator and an enclosed ferrite pot core account for low EMI/RFI, and internal isolation allows for a user-selectable output polarity. A center-tap option permits both positive and negative outputs to be generated from a single low-cost module. The PCB-mount module features two mounting holes and flying leads for the high-voltage connections. The converters are priced below $129.

For More Information Circle No. 753



Medical Signal Processing Amplifier

Teledyne Electronic Technologies, Los Angeles, CA, introduces a family of ultralow-power signal processing amplifiers. The TETMD A110 is a compact analog signal processing amplifier that has all the signal-conditioning elements for processing a variety of biological signals. It has two independent channels, each consisting of an instrumentation amplifier, antialiasing low-pass filter, programmable high-pass filter, programmable gain amplifier, and output buffer. They are housed in a single-in-line package measuring 0.25 × 0.75 × 3 in. The TETMD A110 is priced at $149 each.

For More Information Circle No. 754

Sandblaster for Conformal Coating Removal

Crystal Mark Inc., Glendale, CA, says that its SWAM BLASTER™ Model MV-1L microabrasive sandblaster introduces a precisely graded microabrasive powder into a controlled stream of compressed gas through an abrasive-resistant pathway to safely remove all types of conformal coatings from printed-circuit boards without causing mechanical or ESD damage. The company notes that an environmentally friendly system including the MV-1L, the Point Ionizer™ for neutralizing of static charges, and the new TURBO-station™ work chamber with a built-in dust collector is available for less than $5000.

For More Information Circle No. 759

Integrated Switching Regulators

Power Trends, Warrenville, IL, offers the PT78/79 Series, which it dubs the next generation of integrated switching regulators. They have a maximum output current of 1.5 or 2 A and an input voltage rating of 38 V. The family consists of the PT78ST1 1.5-A positive step-down regulator; the PT78HT2 2-A positive step-down regulator; the PT78NR1 1-A plus-to-minus converter; and the PT79SR1 1.5-A step-down regulator. The Series offers conversion efficiency above 85 percent, and over-temperature and short-circuit protection. The regulators are available for $7.95 each in quantities of 1000.

For More Information Circle No. 755

IC and Component Storage Albums

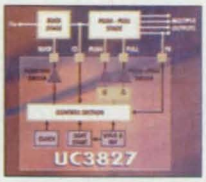
ITOI Enterprises, Newton Highlands, MA, offers a line of album storage containers made of conductive and static-dissipative MIL-SPEC materials that provide ESD-safe, crush-resistant protective packaging for storing, archiving, organizing, and transporting integrated circuits of any form factor, from mini-DIP to ball grid arrays. All versions can be combined with varying inserts and tailored cover graphics to make customized merchandising packages for virtually any type of semiconductor, sensor, or mechanical device. The containers are priced at less than $1.00 each in OEM quantities.

For More Information Circle No. 757

Array Connector for Backplane Connections

AMP Inc., Harrisburg, PA, has designed a high-density array connector system for backplane connections. The Lightray MPX provides up to 12 fiber interconnections in less space than a single SC connector. It also permits pluggable board-to-board interconnections for flexible backplane-based systems in the telecommunications and data networking markets. The connector, designed to meet the requirements of Bellcore GR-1435, is available in single-mode and multimode versions for up to 12 fibers. Typical insertion loss is 0.5 dB for both multimode and single-mode connectors; single-mode reflection loss is -50 dB.

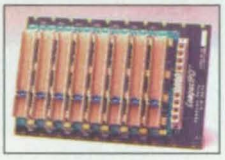
For More Information Circle No. 760



Pulse Width Modulation Controller

The UC3827 family of pulse-width modulation controllers (PWMs) from Unitrode, Merrimack, NH, combines a buck stage with a push-pull stage on one integrated circuit. Features include average current mode, peak current mode, or traditional voltage mode control operation. Recommended operating frequency is up to 500 kHz. The UC3827 is available for both current-fed (UC3827-1) and voltage-fed (UC3827-2) control methods. The device has three outputs, the first controlling an external FET that provides a buck-regulated voltage to the transformer's center tap; the other two drive external FETs for the push-pull stage.

For More Information Circle No. 752



Ten-Layer Backplane

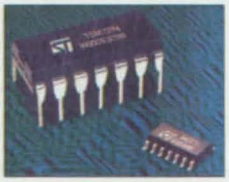
Carlo Gavazzi Electronic Packaging, Brockton, MA, says that its new CompactPCI™ backplane combines the Eurocard format popularized by VMEbus, the IEC 2-mm Hard Metric Connector Specification, and the high performance of PCI silicone. It is a ten-layer design using a combination of stripline and microstrip techniques. Gavazzi says that separate power planes and multiple ground planes provide a low-noise environment needed to achieve superior performance at the high-speed transfer rates required by the PCI specification. They are available in 3U and 6U configurations, with 2 to 8 slots and an optional power-supply connector.

For More Information Circle No. 756

Automated Flip Chip Assembly Cell

Anorad Corp., Hauppauge, NY, says its FCB-5300-VIP flip chip bonder motion platform is designed to provide high-accuracy placement motion over a 10.5-×-16-in. area. The universal gantry-type motion platform allows for conveyorized, reel-to-reel, or magazine-to-magazine type material feeding. The programmable force-control system provides from 30 to 5000 grams of holding force to accommodate flip chip bonding with a variety of materials, soldering, thermal compression bonding, and anisotropic conductive film bonding. Anorad says die placement accuracy is ±5 microns with 1-micron die or substrate measuring accuracy.

For More Information Circle No. 758



Low-Voltage Analog Block

SGS-Thomson Microelectronics, Lincoln, MA, adds the TSM221 to its range of standard linear ICs. Designed as a general-purpose low-voltage analog block for telecommunications, automotive, and consumer applications, the TSM221 provides independent rail-to-rail op amps and two independent comparators housed in a 14-pin DIP or surface-mounting SO package. It draws a supply current of 500 mA (total package at 5 V) and is immune to latchup. Input bias current is 1 pA typically, and with a 1-MHz typical gain-bandwidth product, the chip is specified for a 100-ohm load over a temperature range of -40/+125 °C.

For More Information Circle No. 761

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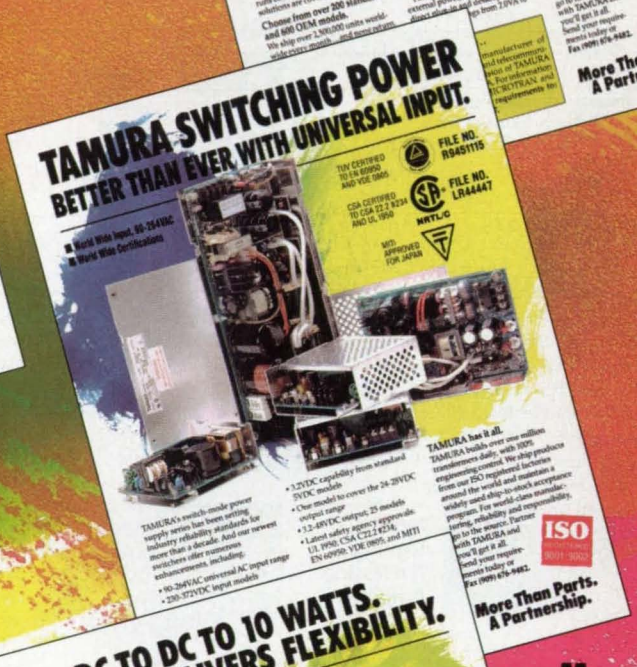

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Continued from page 80

dynamic-stability-prediction simulations and/or by flight testing.

Some examples of simple, single-parameter criteria include those based on (1) Cnβdyn, the dynamic-directional-stability parameter, and (2) the lateral-control-departure parameter (LCDP). These criteria are useful for predicting departure characteristics, but their accuracies may be limited because of simplifying assumptions made in their mathematical derivations. They have not exhibited consistent correlation with results from flight tests at high angles of attack. Also, the information obtained from simulations and flight tests of departure-resistance maneuvers can be limited in that the number of conditions tested is necessarily small in comparison with the total number of possible conditions. The coupling of (1) an infinite number of possible flight conditions and control-input combinations with (2) the complex architectures of modern control systems makes it difficult, at best, to search for possible problem areas in the flight envelope. The limitations of prediction methods of both types increase at high angles of attack, where aircraft dynamics become more complex and aerodynamic effects are nonlinear. Because of the limitations of these methods, NASA is using machine-learning techniques in research directed toward improving on methods of predicting departure resistance.

In support of flight tests of the X-31 airplane at Dryden Flight Research Center, machine learning techniques have been used in computer simulations (see figure) in which one searches for control-input strategies that result in uncontrollable conditions. A genetic algorithm generates quasi-random stick inputs for a high-fidelity X-31 engineering simulation. Each input is evaluated to determine whether it causes the airplane to exceed flight-control limits or whether the states of the airplane become uncontrolled. The genetic algorithm then uses the results of each search iteration and "learns" what types of control-input strategies could lead to departed flight conditions. A major benefit of this automated search is that a very large set of control inputs and flight conditions can be tested without interaction with a pilot. The result of the genetic-algorithm-based search is a final population, or set, of control-input combinations at various points in the flight envelope that lead to potential departures. In addition, the search can reveal aspects of flight-control logic that one might need to analyze further. Once potential departures or problem areas are located in the search, one can conduct a test in which a pilot attempts to duplicate the control inputs or maneuvers in question.

An example of a departure found during such a genetic search is one due to inertial coupling in the X-31 pitch axis. Inertial-coupling departures have been seen during other flight-test programs; they are typical of highly agile fighter airplanes with small roll and large pitch moments of inertia. An inertial-coupling departure occurs when a pilot or automatic-flight-control logic is unable to compensate for inertial effects caused by a rapid, cross-axis maneuver. For example, inertial coupling occurs during rapid rolls and roll reversals performed in conjunction with rapid changes in pitch. The inertial-coupling departure located by the genetic search with the X-31 simulation occurred when multiple rolls at low angles of attack were performed with changes of pitch from negative to positive angles of attack. During the departure, pitch control and lateral directional control could not overcome the inertial coupling in the pitch axis. Such maneuvers could occur during air combat, when oblique turns are performed and pilots frequently change maneuver plane of the aircraft in efforts to aim weapons. Because of the discovery of the inertial-coupling departure in the genetic search and simulation, and because inertial-coupling incidents had been observed in other flight-test programs, multiple rolls at low angles of attack were prohibited during flight test of the X-31.

Another example of a departure located by genetic search includes one, found during expansion of the X-31 flight envelope, caused by asymmetries in aerodynamics. Though there are slight differences and simplifications between the simulation models and the real aircraft, the results of this research have shown that it is possible to use machine-learning techniques to identify potential controllability problems that can later be verified or avoided during flight test.

This work was done by Wes Ryan of PRC, Inc., for **Dryden Flight Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mathematics and Information Sciences category,* ***or circle no. 110*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

DRC-95-38

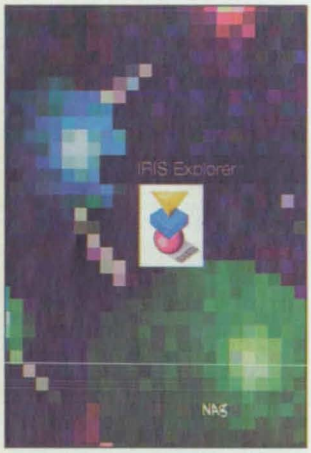
New Literature

Catalog AP-597 from Bimba Manufacturing, Monee, IL, describes **linear thrusters, rotary actuators, and rodless cylinders**. Included are Pneu-Turn® rotary actuators, Ultran® rodless cylinders, and Bimba Transition Plates, which allow users to couple actuators into multi-axis configurations.

For More Information Circle No. 701

Otto Controls, Carpentersville, IL, has released an 80-page catalog of **switches,** including pushbutton, toggle, sealed rocker, sealed limit, special purpose, basic, domed-shaped pushbutton, and sealed pendant. Current levels are available from computer level to 16 amperes.

For More Information Circle No. 702



IRIS Explorer™ **visual programming software** from Numerical Algorithms Group, Downers Grove, IL, is described in a four-page brochure. Used for data visualization, animation, manipulation, and analysis, the program allows engineers to create applications for displaying and analyzing complex multi-dimensional data sets interactively.

For More Information Circle No. 708

Superbolt, Carnegie, PA, has released a catalog describing **mechanical stud/bolt tensioners** for replacement of tightening methods such as hydraulic tensioning, thermal tightening, and use of a sledgehammer or wrench. Expansion bolts, torque nuts, torque bolts, jamnuts, and load cells are featured.

For More Information Circle No. 706

A 464-page catalog of **data acquisition and control products** is available from KineticSystems, Lockport, IL. Scanning A/D converters, signal conditioning products, data acquisition software, distributed I/O systems, transient recorders, and VXI, CAMAC, and H-TMS data acquisition equipment are included.

For More Information Circle No. 703

Interactive Image Technologies, North Tonawanda, NY, offers a 16-page brochure describing Electronics Workbench® EDA PC-based **A/D simulator** that offers integrated schematic capture, mixed A/D simulation, and waveform capabilities. The program features more than 8,000 analog and digital device models.

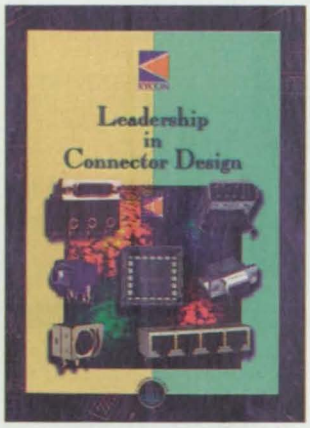
For More Information Circle No. 704

An 18-page brochure from Howmet Corp., Greenwich, CT, describes **castings** made of superalloy, titanium, and aluminum alloys. Equiax, directionally solidified, and single crystal casting technologies are offered.

For More Information Circle No. 705

Printec USA Electronics, Santa Ana, CA, offers a brochure describing **printed circuit boards.** Included are multilayer and double-sided boards, back panels, PCMCIA, and flexible circuit boards.

For More Information Circle No. 700



A 100-page catalog from Kycon, San Jose, CA, describes **connectors** such as D-subminiature, composite coax, DIN, and mini-DIN styles. Related products include modular jacks and plugs, DC power connectors, chip carrier sockets, card edge connectors, and cables and adapters.

For More Information Circle No. 707

For More Information Circle No. 430

For More Information Circle No. 431

New on the Market

Product of the Month

Hewlett-Packard, Palo Alto, CA, has introduced the Infinium family of **oscilloscopes** with bandwidths from 500 MHz to 1.5 GHz; maximum sample rates per channel of 1 Gsa/s, 2 Gsa/s, 4 Gsa/s, and 8 Gsa/s; and memory depth of 32K to 64K/channel. The instruments provide users with an analog-like front panel, a Windows 95-based graphical user interface, and a built-in information system. Features include separate scaling and positioning controls for each channel; clear trigger-setup information; and a waveform display area of 26.8 square inches. Five models, with either two or four channels, are available from $9,995.

For More Information Circle No. 723

Micro Alliance, Vista, CA, has introduced the Model 810TX Pentium™ 200 MHz **portable computer** that features a 12.1" active matrix color display with six user PCI expansion slots. It comes with a 120 MHz to 200 MHz Pentium processor, up to three drives—either a 3.5" or 5.25" device—and a 300-watt power supply for 115/230 VAC or optional 24/48 VDC operation. The computer measures 13 x 19 x 15" and can be rack-mounted or carried in a shock-resistant case.

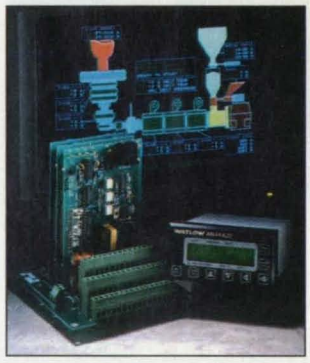
For More Information Circle No. 732

The Ultra-HiBrite-14 large-format **flat panel display** from Computer Dynamics, Greenville, SC, features a 13.8" color TFT LCD with 800-nit brightness. It is available in XGA resolution with 256k colors, or VGA with 16.7 million colors. The display can be configured as a Pentium-based flat panel computer, or in a choice of two flat panel monitor platforms. Display sizes of 10.4", 8.4", and 6.4" also are available.

For More Information Circle No. 725

The UT-Series **industrial adhesives** from Sony Chemicals Corp. of America, Mount Pleasant, PA, utilize UV curing chemistry and feature variable thickness, elasticity to fit in and around complex geometries, the ability to bond on one or both sides, water and heat resistance, and supported and unsupported versions. One side of the tape is acrylic for high peel strength; the other side is silicone for water resistance.

For More Information Circle No. 728



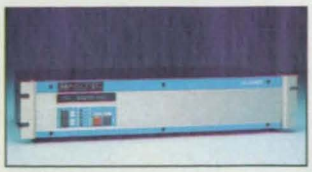
Watlow Electric Manufacturing, St. Louis, MO, has introduced the Anafaze MLS **temperature control system** that allows control of up to 32 independent temperature channels with various sensor inputs. It features a 2x16 backlit LCD alphanumeric display for data setup and monitoring, and accepts thermocouples, RTDs, linear current, or voltage as sensor inputs. The system includes 35 digital outputs and 8 digital inputs to be used as control outputs, alarm outputs, and for remote job selection.

For More Information Circle No. 727

The LSF permanent-magnet **linear motor** from Indramat, Hoffman Estates, IL, features frameless direct-drive motors that simultaneously increase feed rates, stiffness, and path accuracy. It consists of a primary with three-phase winding, and one or more permanent-magnet secondaries. Forty motor sizes are available, providing peak velocities to 200 m/min.

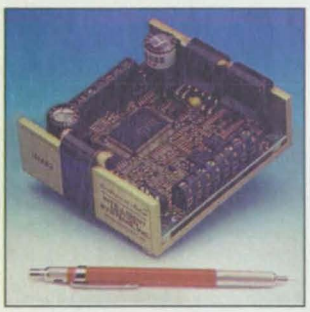
For More Information Circle No. 722

New on the Market



Sensotec, Columbus, OH, offers the Model SC Series digital, multi-channel, microprocessor-based **signal conditioners** for use with strain gauge transducers and other sensors. The units can accommodate up to 14 channels and feature a menu-driven setup interface via front panel controls, and an RS-232/485 interface.

For More Information Circle No. 729



Intelligent Motion Systems, Marlborough, CT, offers the IM483 **microstepping system,** which accepts input voltages to 48 volts, with 3.0 amps RMS current to each phase. The driver uses surface-mount and ASIC technologies, and measures 3" x 2.75" x 1.2". Fourteen built-in microstep resolutions can be changed without resetting the driver, allowing the user to move long distances rapidly.

For More Information Circle No. 721

New Way® **air bearings** from New Way Machine Components, Aston, PA, offer gimbaled mountings and threaded ball studs. They feature zero static friction, no moving parts, and pressurized air film. They do not use oil or grease lubrication and can be run against any flat surface, including granite, ceramic, glass, plastic, and non-corrosive metals.

For More Information Circle No. 731

The evolution MOUSE-TRAK® **input device** from ITAC Systems, Garland, TX, features pre-programmed keys that perform common functions of conventional three-button mouses, including primary click, primary double-click, primary drag, and right click. It incorporates ruggedized bearings, a contoured palm and wrist support pad, and is self-cleaning.

For More Information Circle No. 720

Device Technologies, Marlborough, MA, has introduced Spring-Fast® T Series and BT Series **grommet edging** to protect electrical cables and hoses from abrasion caused by rough sheet metal edges. The polymer grommets are made of nylon-coated stainless steel with a 90 Durometer Shore A cushion and require no adhesives for installation; gripping fingers allow it to be snapped into place. It is available in several sizes for sheet thicknesses of 0.025" to 0.250".

For More Information Circle No. 724

Nook Industries, Cleveland, OH, has released the Powerac Plus™ **screws and travel nuts** for precision components in repeatable linear delivery systems. The Preload Nut features a three-piece design made from pre-lubed material, and has an enclosed adjustable spring. The Powerac Plus screws are made of 304 stainless steel and come in sizes through 1" diameter. High temperature materials for environments to 300°F are available.

For More Information Circle No. 730

New on Disk

MathSoft, Cambridge, MA, has announced Mathcad 7 Professional **technical calculation and data analysis software** that complements Microsoft Office. The software enables users to solve problems from simple arithmetic to advanced symbolic algebra and differential equations. MathConnex™ allows creation of models and systems by integrating other applications and data with Mathcad computations. It is available for Windows 95 and NT at $399.95.

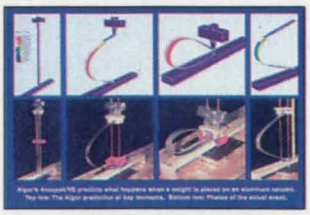
For More Information Circle No. 716

IBM, White Plains, NY, has released Version 4, Release 1.8 of CATIA-CADAM Solutions **design, simulation, and manufacturing software** that includes eight new products and 45 enhancements. Expanded Generative Shape Modeling offers tools for continuing the styling process within CATIA; and Surface Machining Programmer and Multi-Axis Machining Programmer modules enable interactive semi-automatic machining.

For More Information Circle No. 715

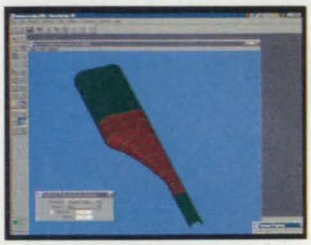
Intergraph Corp., Huntsville, AL, has released Version 2.0 of Imagineer™ Technical **2D CAD software** that features Web integration, enhanced dimensioning and annotation, and 2D kinematic animation capabilities. The native Windows program can read and write MicroStation® and AutoCAD files, and enables freehand sketching. The software is Microsoft Office 97 compatible.

For More Information Circle No. 710



Algor, Pittsburgh, PA, offers Accupak/VE **engineering software** that combines kinematics, rigid/flexible body dynamics, and nonlinear stress analysis. It simultaneously analyzes mechanical events involving large-deformation, nonlinear material properties, kinematic motion, forces caused by motion, and stress prediction.

For More Information Circle No. 712

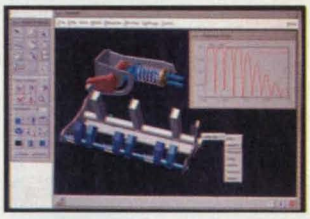


Bentley Systems, Exton, PA, has released an enhanced version of MicroStation Modeler® **solid modeling software** with integrated surface modeling that allows users to sketch freeform. Users can combine surface and solid modeling techniques while maintaining the history of all commands. It supports Windows 95/NT, Power Macintosh, Sun SPARC, Hewlett-Packard RISC, Silicon Graphics, and Digital Equipment Alpha platforms.

For More Information Circle No. 711

MiniCAD 7 **2D-3D cross-platform CAD software** from Diehl Graphsoft, Columbia, MD, is a 32-bit program supporting Windows 95, NT, and 3.1, as well as Macintosh. It features surface, solid, and wireframe modeling; support for Apple's QuickDraw 3D rendering; the ability to attach data to graphical objects; rotation of the working grid and coordinate system to any angle; and the ability to open and save native AutoCAD DWG files.

For More Information Circle No. 713



Version 9.0 of ADAMS **mechanical system simulation software** from Mechanical Dynamics, Ann Arbor, MI, enables users to create and test virtual prototypes, simulating full-motion behavior of mechanical system designs. Enhancements include a graphical user interface for Motif and Windows, animation during simulation, and easier application of parameterization. It runs on Windows 95 and NT, and on UNIX-based workstations.

For More Information Circle No. 717

EASE Version 2 **data analysis software** from SoMat Corp., Champaign, IL, provides an integrated environment for analysis of performance, noise, and vibration data, and durability of mechanical assemblies and sub-assemblies. It works with up to 100 data sets of unlimited size from sources such as Matlab, DADiSP, and TEAC.

For More Information Circle No. 718

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Bal Seal Engineering Company, Inc.		463	13a
Ballistic Missile Defense Organization	www.futron.com/bmdo/sbir.html	445	79
BASF Corporation		588	63
Belt Technologies	www.BeltTechnologies.com	615,479	26N,31N
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Center for Technology Commercialization	www.ctc.org	549	34N
Cerac Incorporated	www.cerac.com	424	70
Circuit Specialists Inc.	www.cir.com		80A-D
Columbia Research Laboratories, Inc.		428	75
Corel Corporation	www.corel.com	519	33
Cybernetics			37
Data Instruments		616,535	16N,17N
Datum Inc.	www.datum.com.	412	16
Digi-Key Corporation	www.digikey.com	509	5
Dolch Computer Systems, Inc.	www.dolch.com	413	30
DuPont			18-19
DuPont Krytox	www.lubricants.dupont.com	526	55
DuPont Vespel	www.dupont.com/enggplolymers	529	60-61
ebm/Papst	www.ebm.com	450	17a
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Ergotron	www.ergotron.com	440	26
Folsom Research	www.folsom.com	506	2
Foster Miller	www.foster-miller.com	613,478	27N,30N
Gage Applied Sciences Inc.	www.gage-applied.com	520	35
Government Micro Resources, Inc.	www.gmri.com	516	25
Helical Products Company, Inc.	www.Heli-Cal.com	432	84
Hewlett-Packard Co.		586	87
Hewlett-Packard Company	www.hp.com/go/technical		10-11
Hewlett-Packard Basic Instruments	www.hp.com/info/bidaq1	521	39
Hewlett-Packard Co. VEE	www.hp.com/go/hpvee	514	23,48A-B
Hitachi Denshi America., Ltd.		422	71
Hytel Group	www.hytel.com	601	20a
IBI Systems Inc.		585	87
Inframetrics	www.inframetrics.com	622,541	20N,21N
Instrumented Sensor Technology		435	85
Integrated Systems, Inc.	www.isi.com	513	15
Intergraph Software Solutions	www.intergraph.com/solidedge	517	27
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IOtech, Inc.	www.iotech.com	401-407	64A-B
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LPKF Cad/Cam Systems, Inc.		465	18a
Lumitex, Inc.		461	1a
Macsyma Inc.		610,475	13N
Massachusetts Institute of Technology	www-caes.mit.edu	612,477	28N,32N
Massachusetts Office of Business Development	www.state.ma.us/mobd	548	34N
Master Bond Inc.		427,437	74,86
MathSoft, Inc.	www.mathsoft.com/mathcad	539	COV IIN
The MathWorks, Inc.	www.mathworks.com/ntb	512,614	16A-B,17,27N
Melcor	www.melcor.com	462	11a
Microcal Software, Inc.	www.microcal.com	617,536	14N,15N
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Microstar Laboratories	www.mstarlabs.com	583	87
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Motorola	http://motorola.com/sps		6a-7a
National Instruments Corporation	www.natinst.com, www.natinst.com/HiQ	500,414	COV II,34
National Technology Transfer Center	http://ntas.techtracs.org	533	COV III
North American Capacitor Company	www.nacc-mallory.com	600	20a
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Omron	www.oei.omron.com	457	9a
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Sensors Expo Detroit		532	19a
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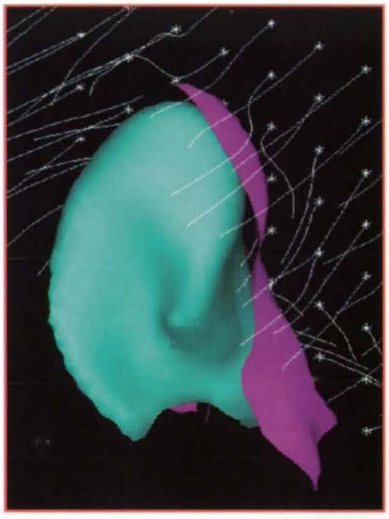

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